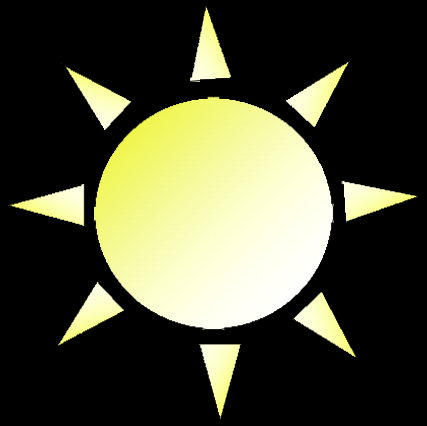
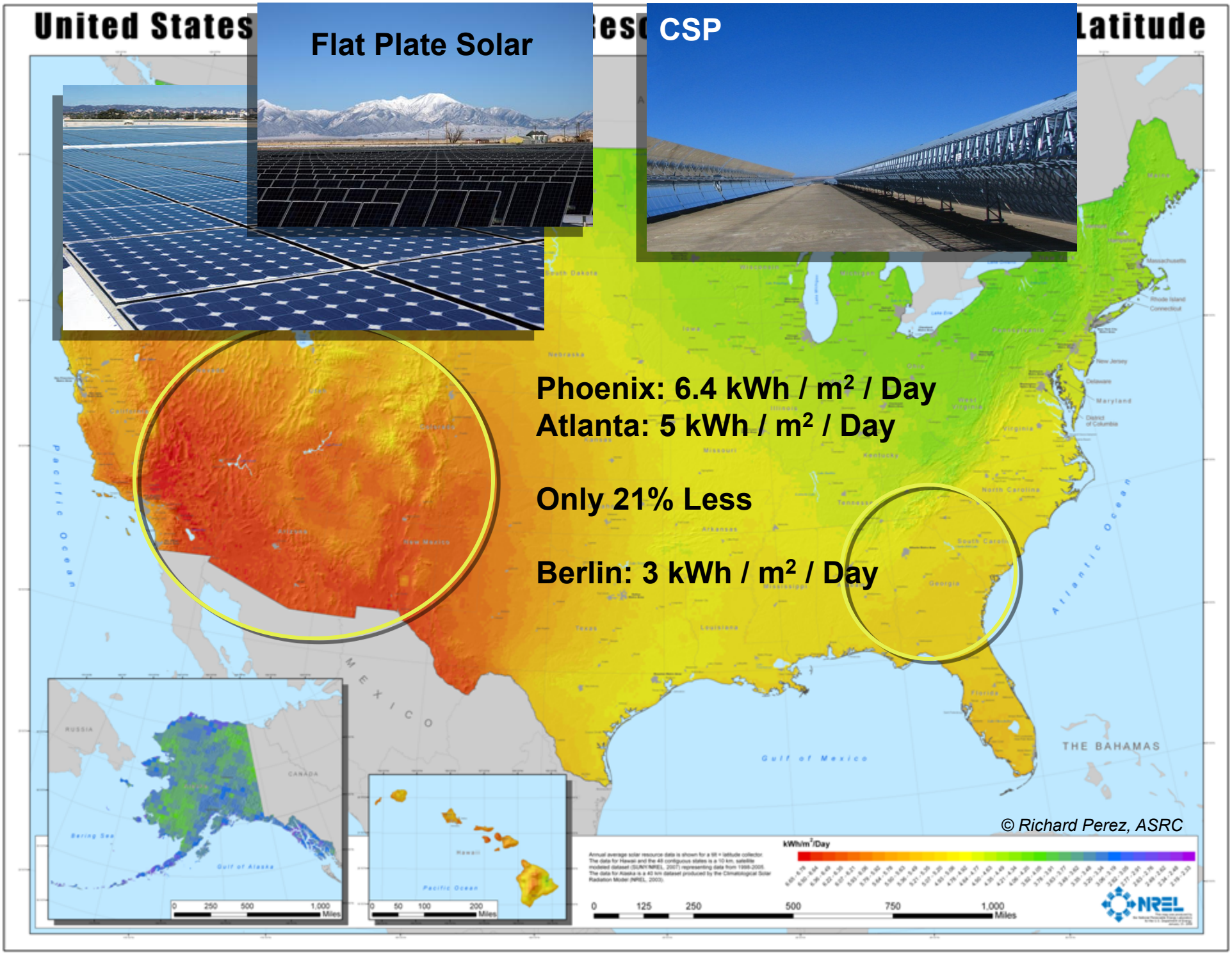
WHY SOLAR ENERGY MAKES SENSE IN GEORGIA

Richard Perez
ASRC, U. Albany

SOLAR RESOURCE



- NOT ENOUGH SPACE,
- NOT ENOUGH SUN,

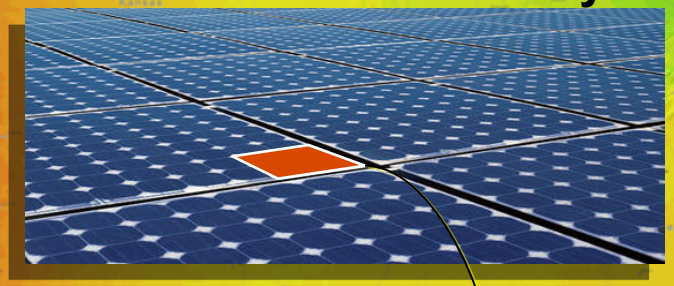

United States
Latitude
Flat Plate Solar
CSP
Phoenix: 6.4 kWh / m² / Day
Atlanta: 5 kWh / m² / Day
Only 21% Less
Berlin: 3 kWh / m² / Day
Pacific Ocean
Atlantic Ocean
Gulf of Mexico
MEXICO
THE BAHAMAS
RUSSIA
CANADA
Bering Sea
Gulf of Alaska
Hawaii
Pacific Ocean
kWh/m²/Day
0 125 250 500 750 1,000 Miles
0 250 500 1,000 Miles
0 50 100 200 Miles
NREL
© Richard Perez, ASRC

United States Concentrating Solar Normal

Phoenix: 6 kWh / m²/ Day
Atlanta: 3.2 kWh / m² / Day

46% Less

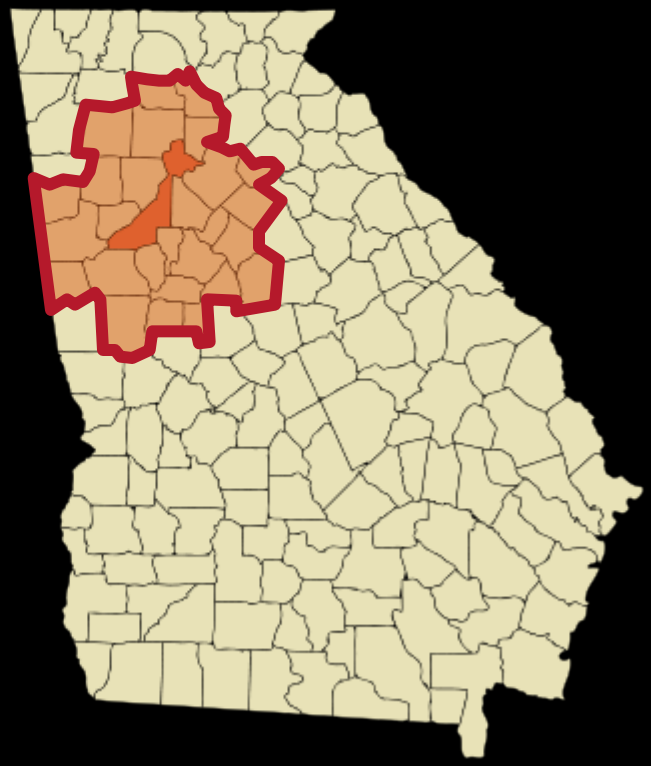
United States Photovoltaic Solar Resource : Flat Plate Tilted at Latitude



Atlanta: 5 kWh / m² / Day

Each PV Ft² can produce
30 kWh per year

Atlanta Metro: 7,900 TWh per year

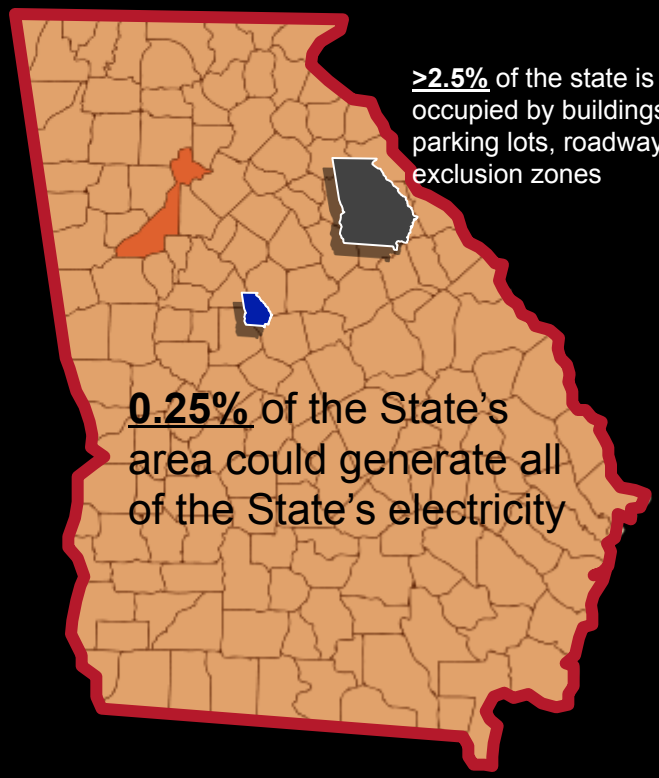


Each PV Ft^2 can produce
30 kWh per year

Atlanta Metro: 7,900 TWh per year

Georgia: 55,000 TWh per year

Each PV Ft^2 can produce
30 kWh per year

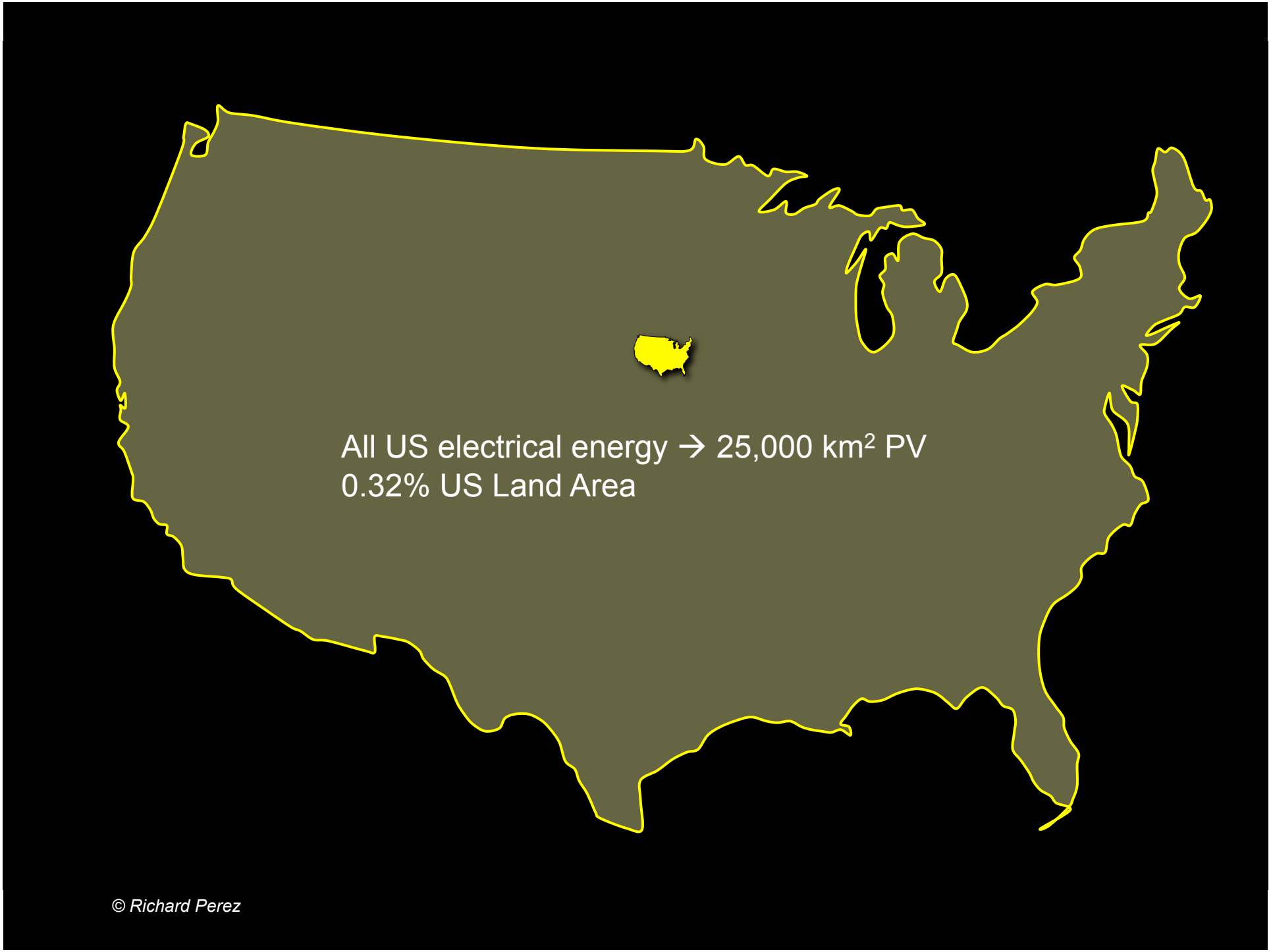


Atlanta Metro: 7,900 TWh per year

Georgia: 55,000 TWh per year

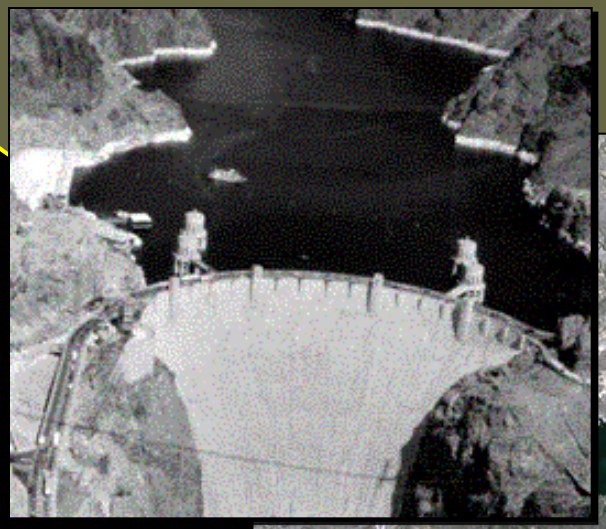
Georgia consumes 140 TWh of electricity

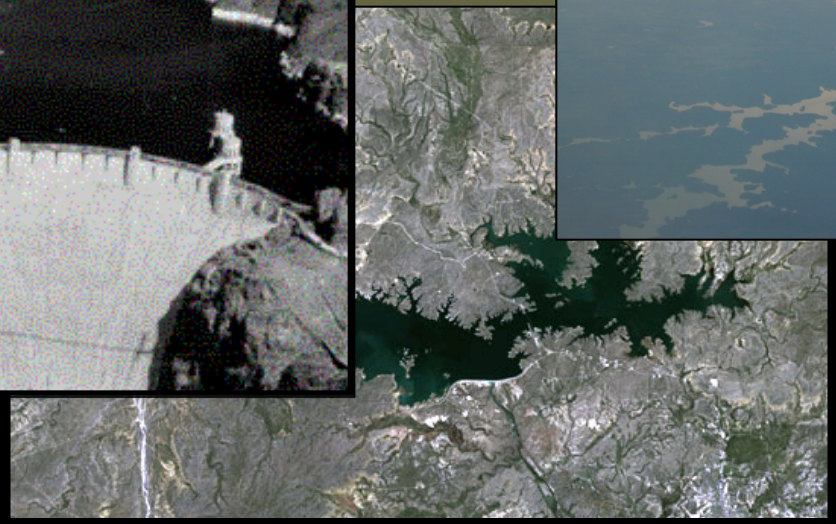

10 kW
2 MW
50 MW
© Richard Perez, ASRC

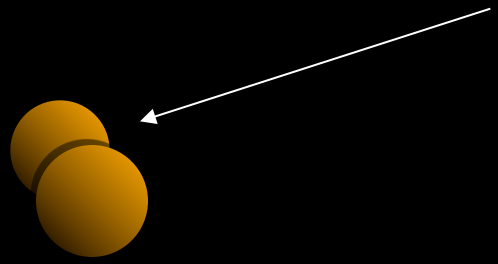


7% US electricity

Hydropower artificial lakes > 100,000 km^2



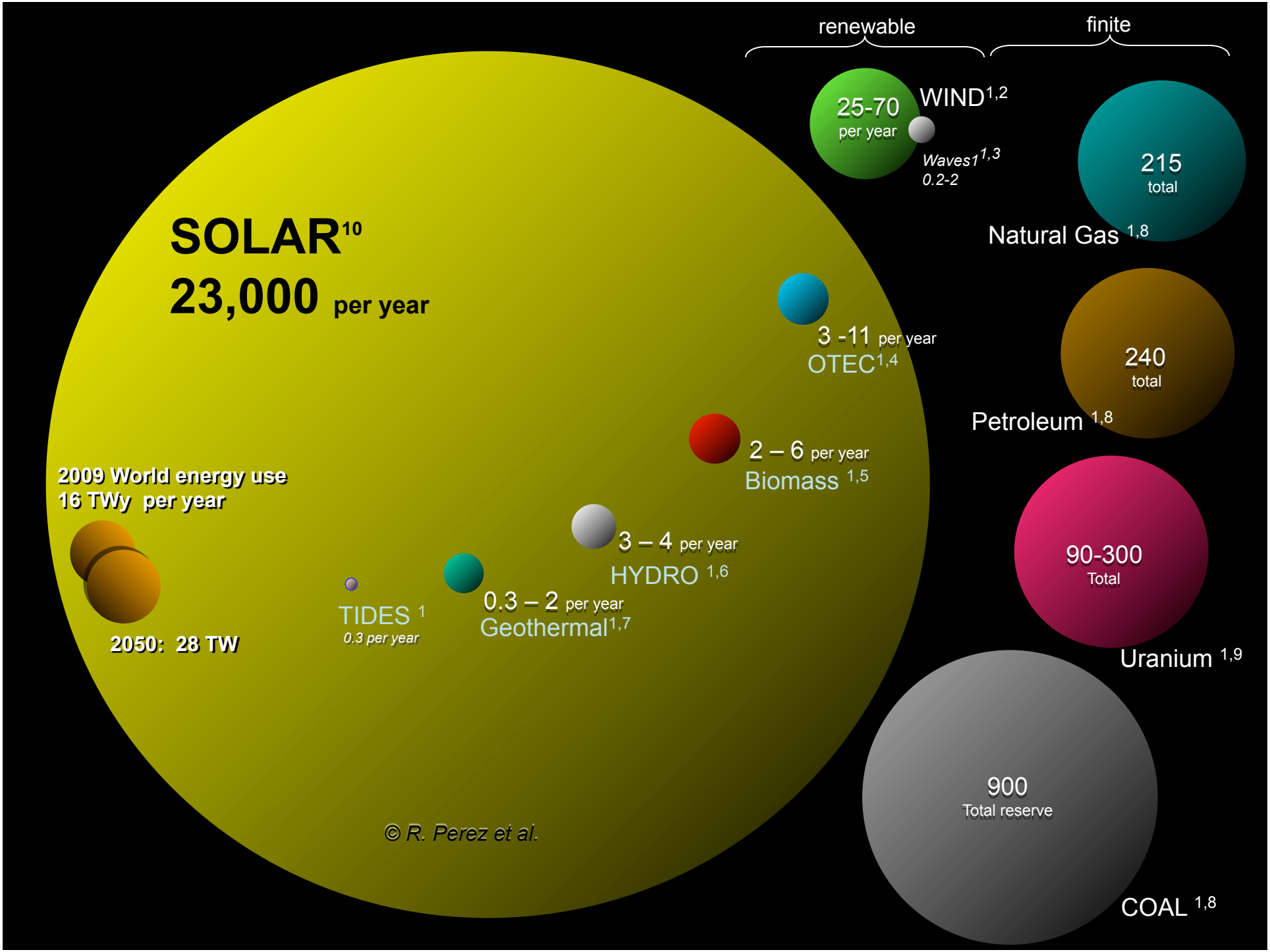


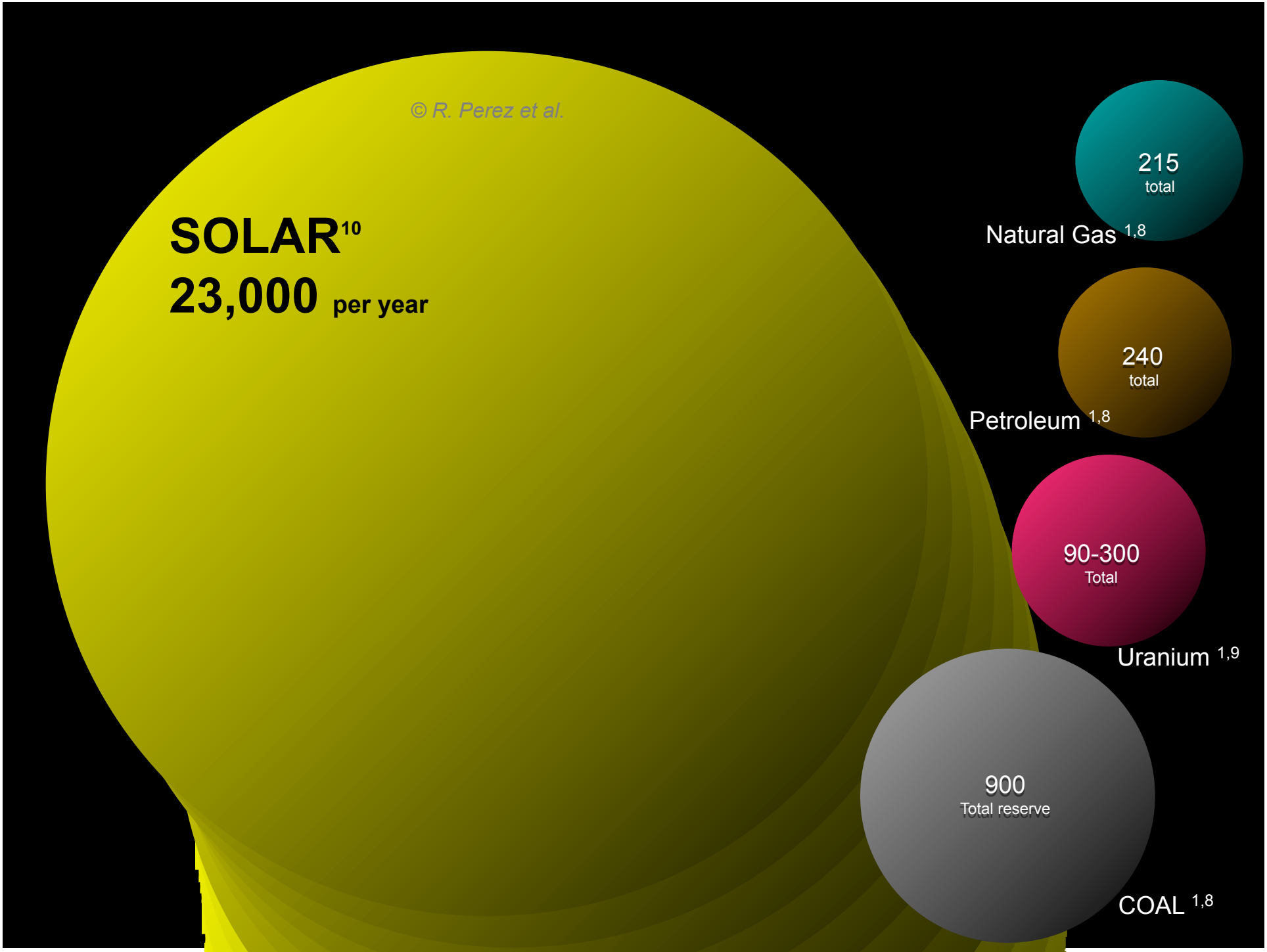


WORLD TOTAL ENERGY USE

2009: 16 TWy

2050: 28 TWy


renewable
finite
SOLAR[10]
23,000 per year
25-70
per year
WIND[1,2]
Waves1[1,3]
0.2-2
215
total
Natural Gas [1,8]
3 -11 per year
OTEC[1,4]
240
total
Petroleum [1,8]
2 – 6 per year
Biomass [1,5]
2009 World energy use
16 TWy per year
3 – 4 per year
HYDRO [1,6]
90-300
Total
Uranium [1,9]
TIDES [1]
0.3 per year
0.3 – 2 per year
Geothermal[1,7]
2050: 28 TW
900
Total reserve
COAL [1,8]
© R. Perez et al.


© R. Perez et al.
SOLAR[10]
23,000 per year
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90-300
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900
Total reserve
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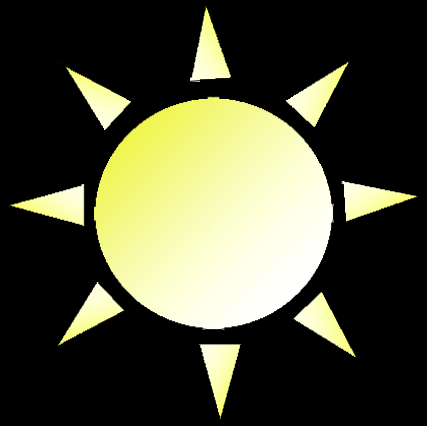
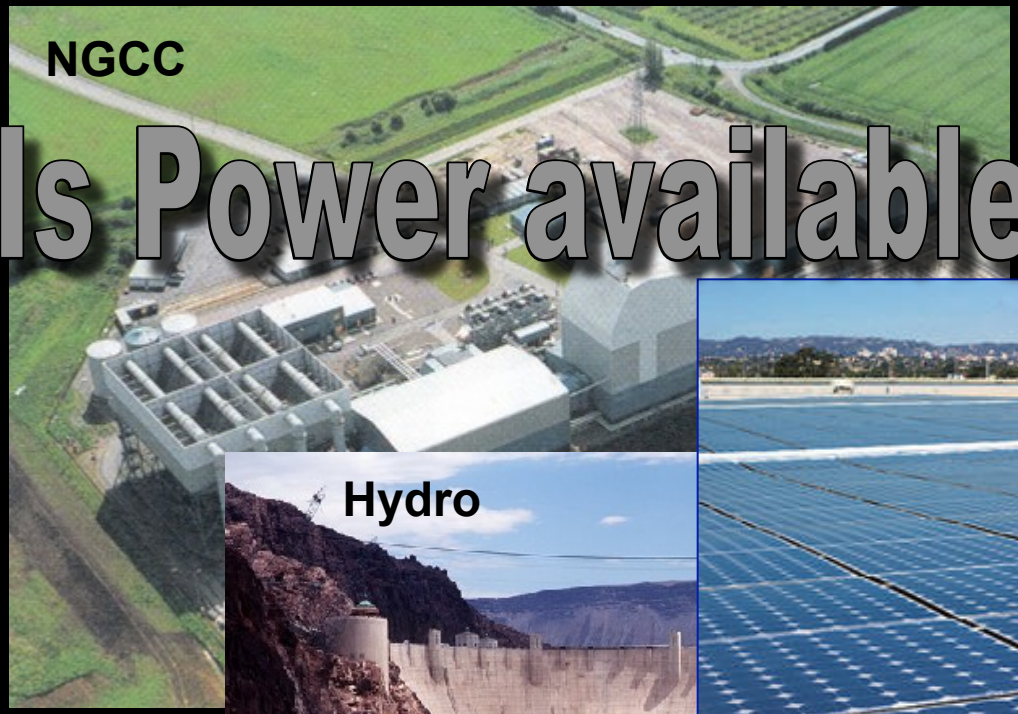
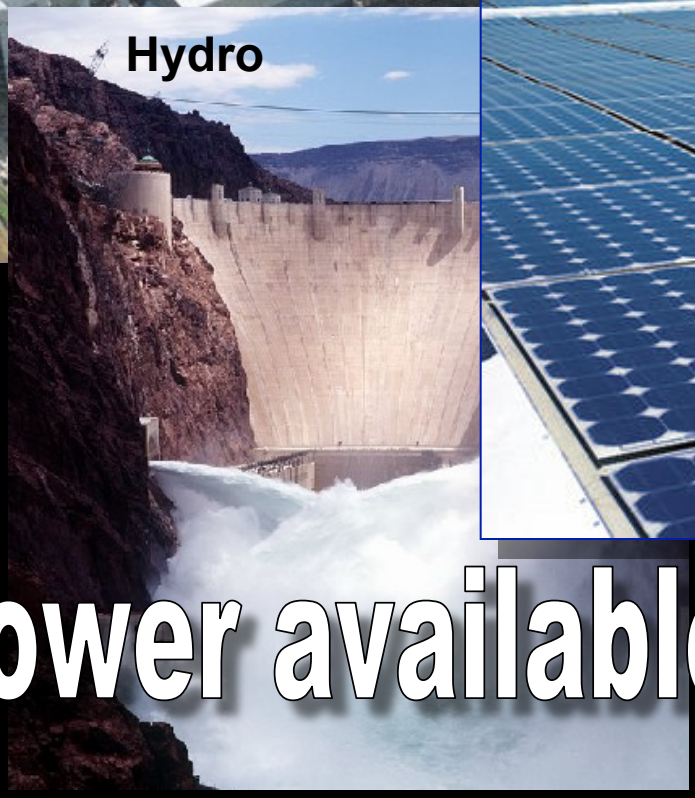
SOLAR RESOURCE



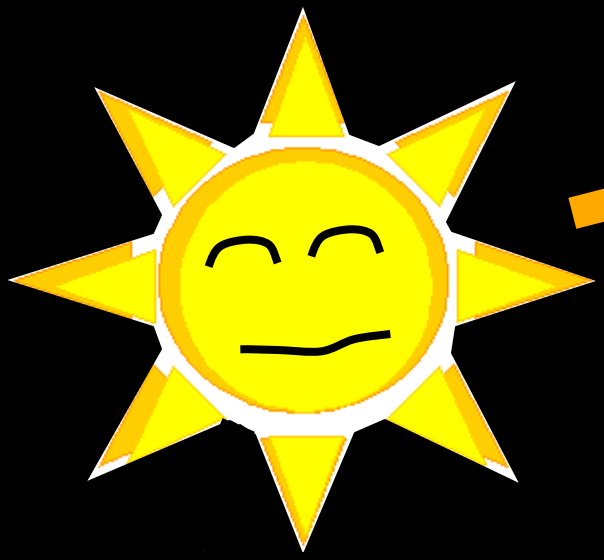
- ~~NOT~~ ENOUGH SPACE,
- ~~NOT~~ ENOUGH SUN,
- NOT RELIABLE



Is Power available on demand?

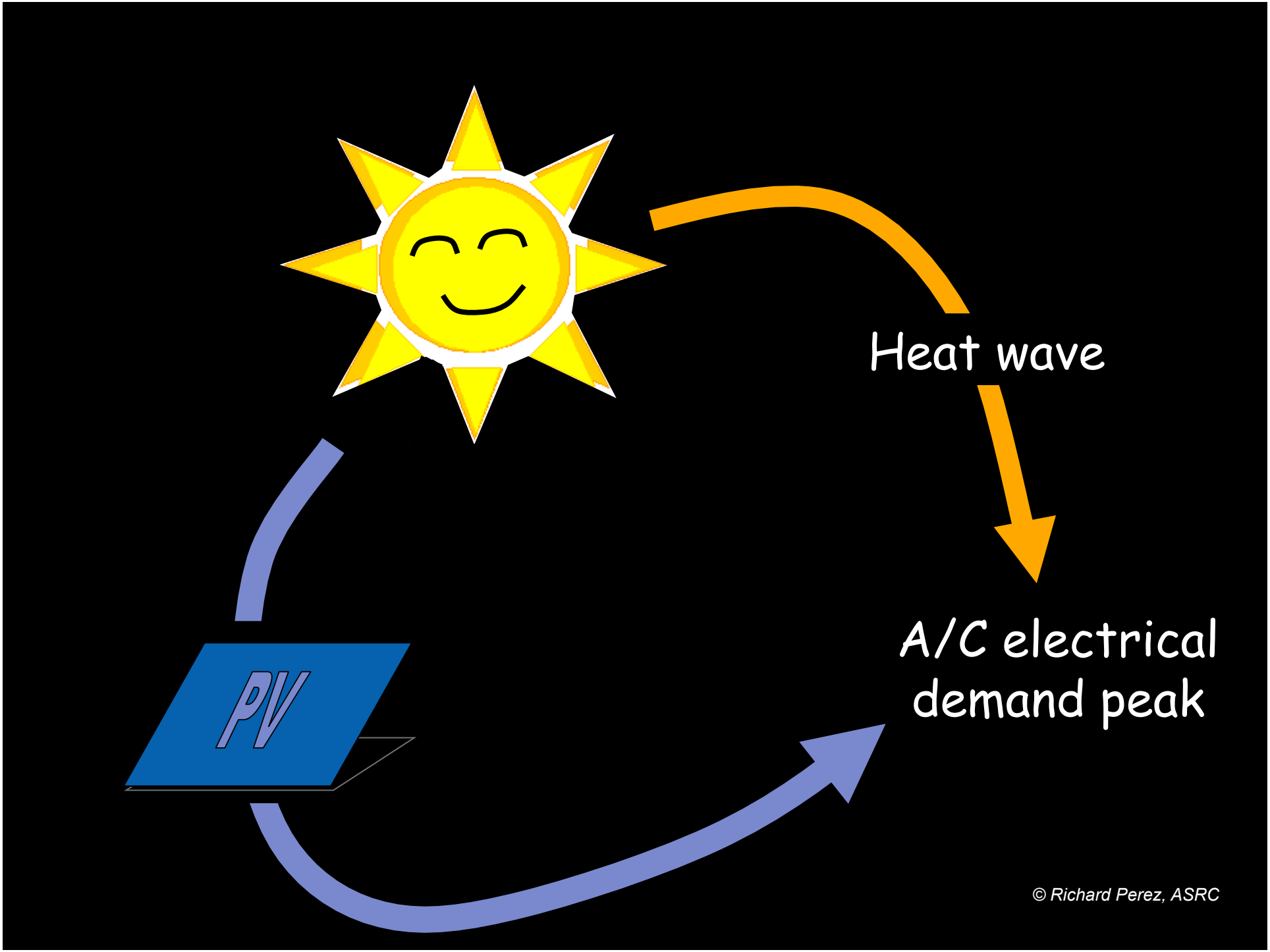


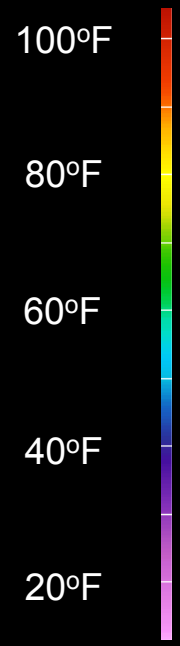
Is Power available when needed?

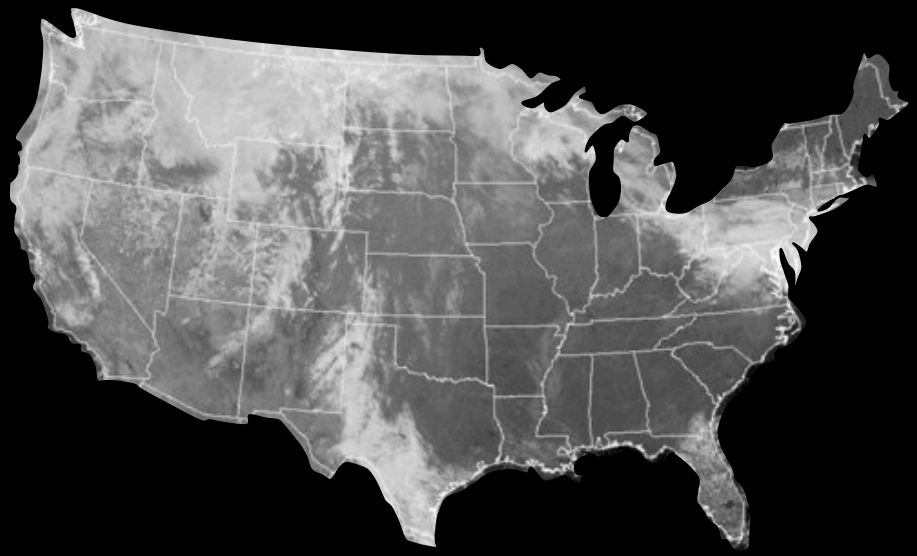


Heat wave

A/C electrical demand peak


Heat wave
A/C electrical
demand peak
PV
© Richard Perez, ASRC

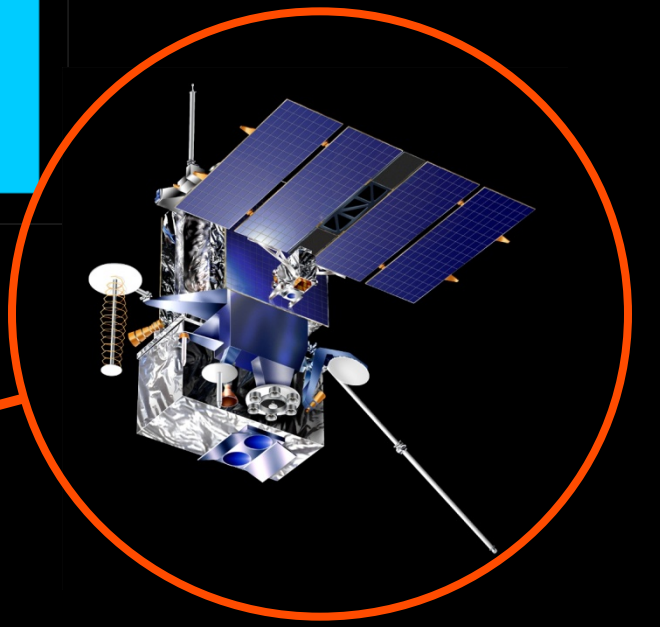




EFFECTIVE CAPACITY
% NGCC EQUIVALENCE

Is Power available when needed?

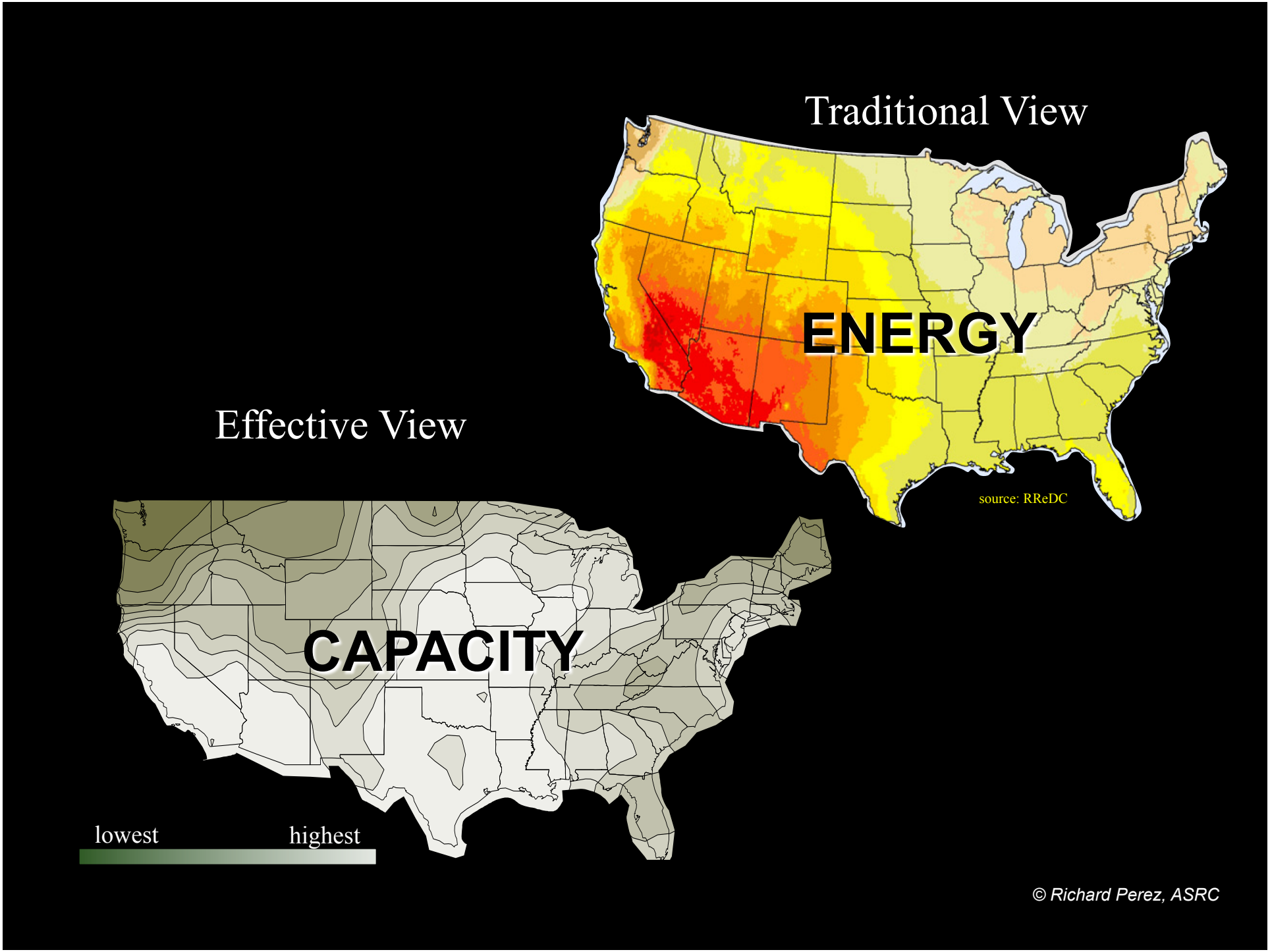
Exhaustive study 100+ utility load-years

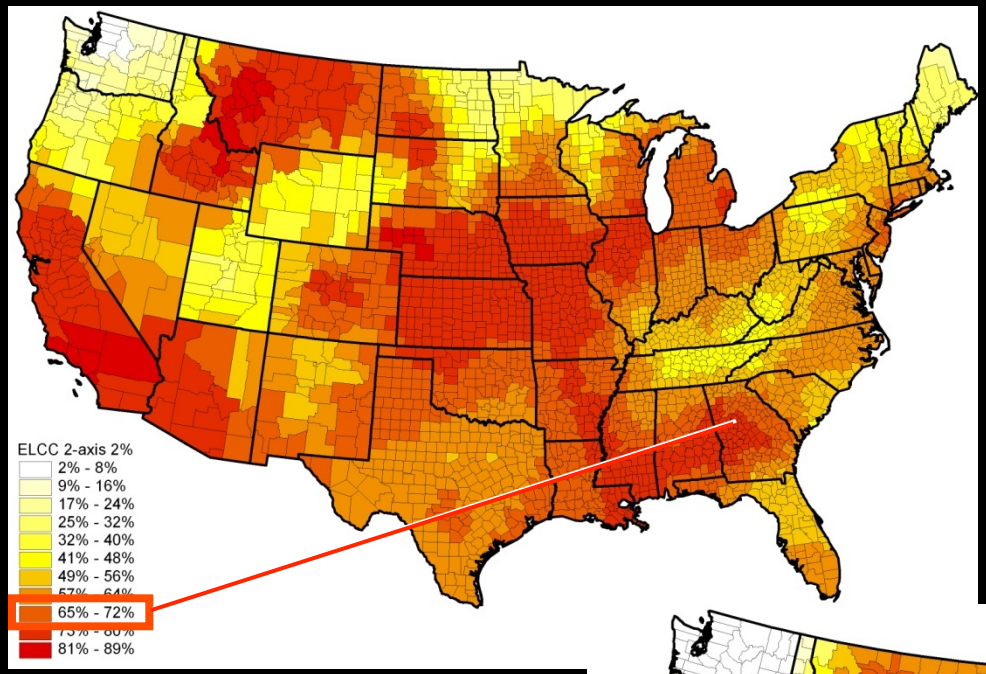


Real time load data

Real time solar resource data

Perez et al., ASRC

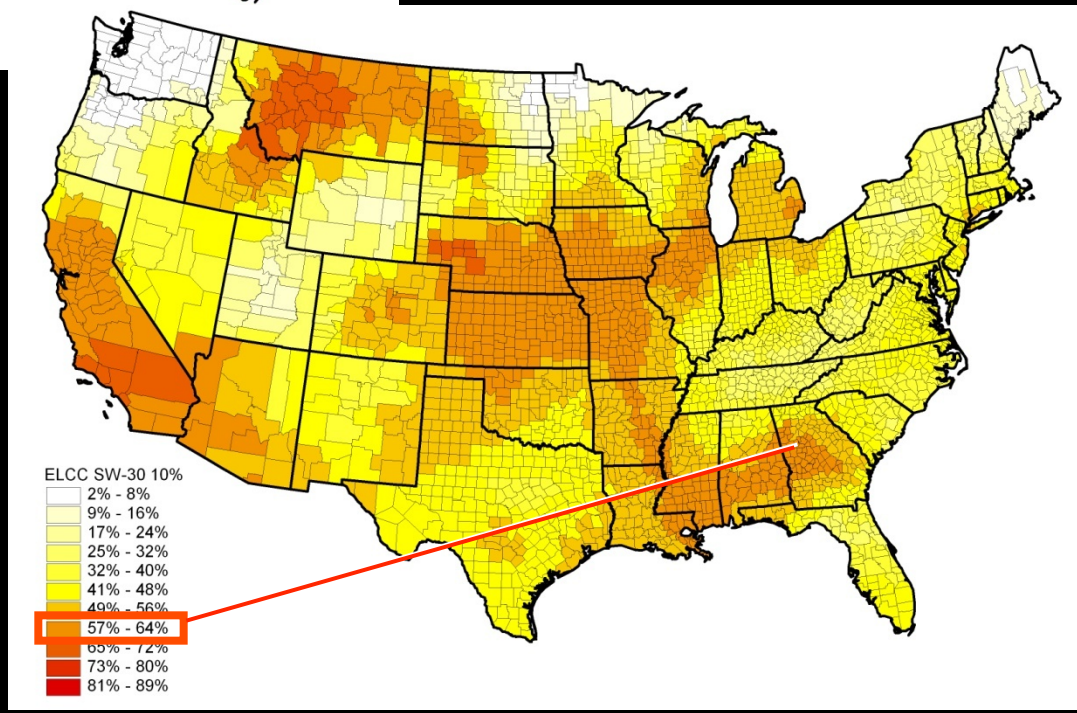

Traditional View
ENERGY
source: RReDC
Effective View
CAPACITY
lowest
highest
© Richard Perez, ASRC



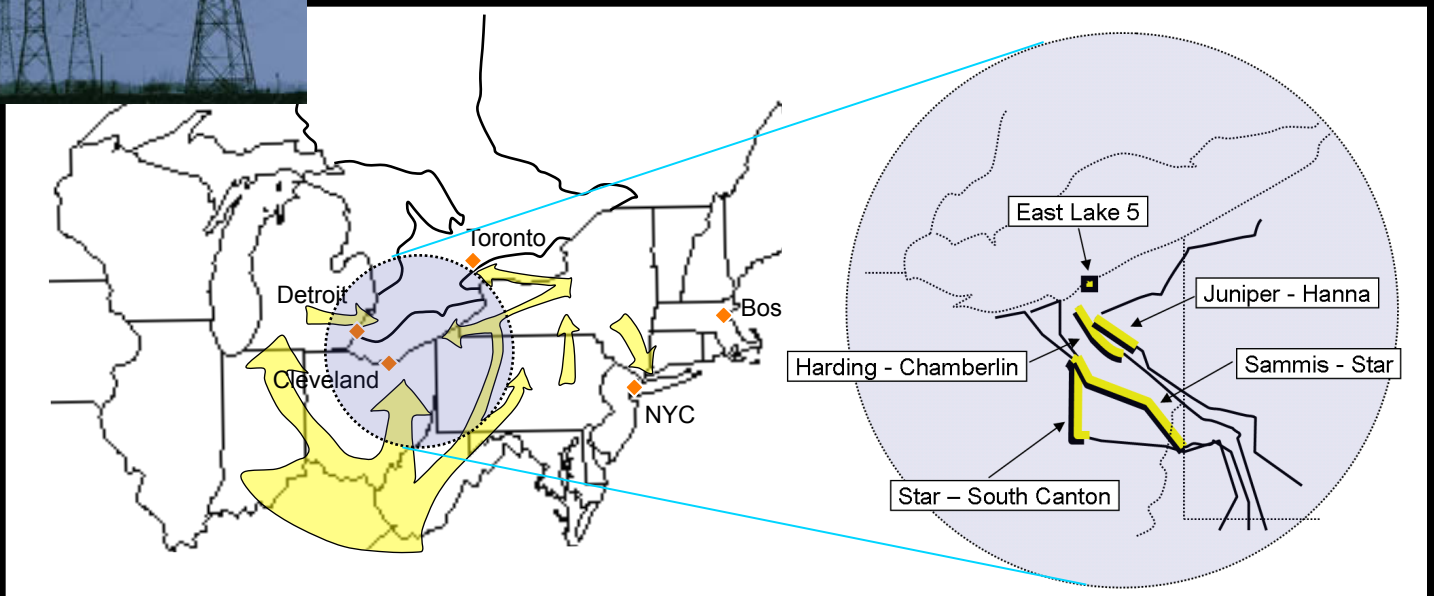
Tracking PV
2% penetration

% NGCC EQUIVALENCE

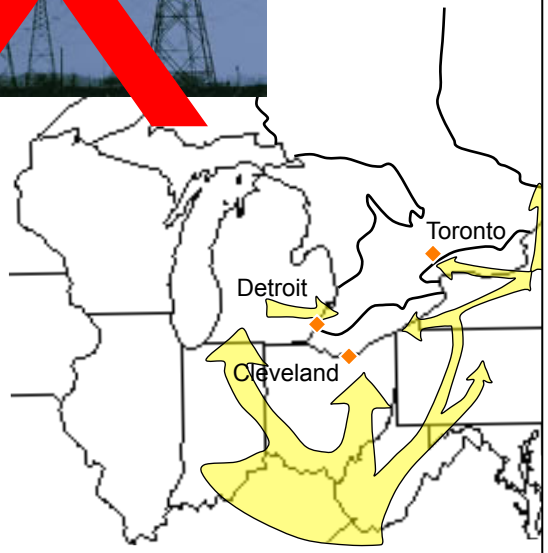
Southwest facing
Low-tilt PV
10% penetration



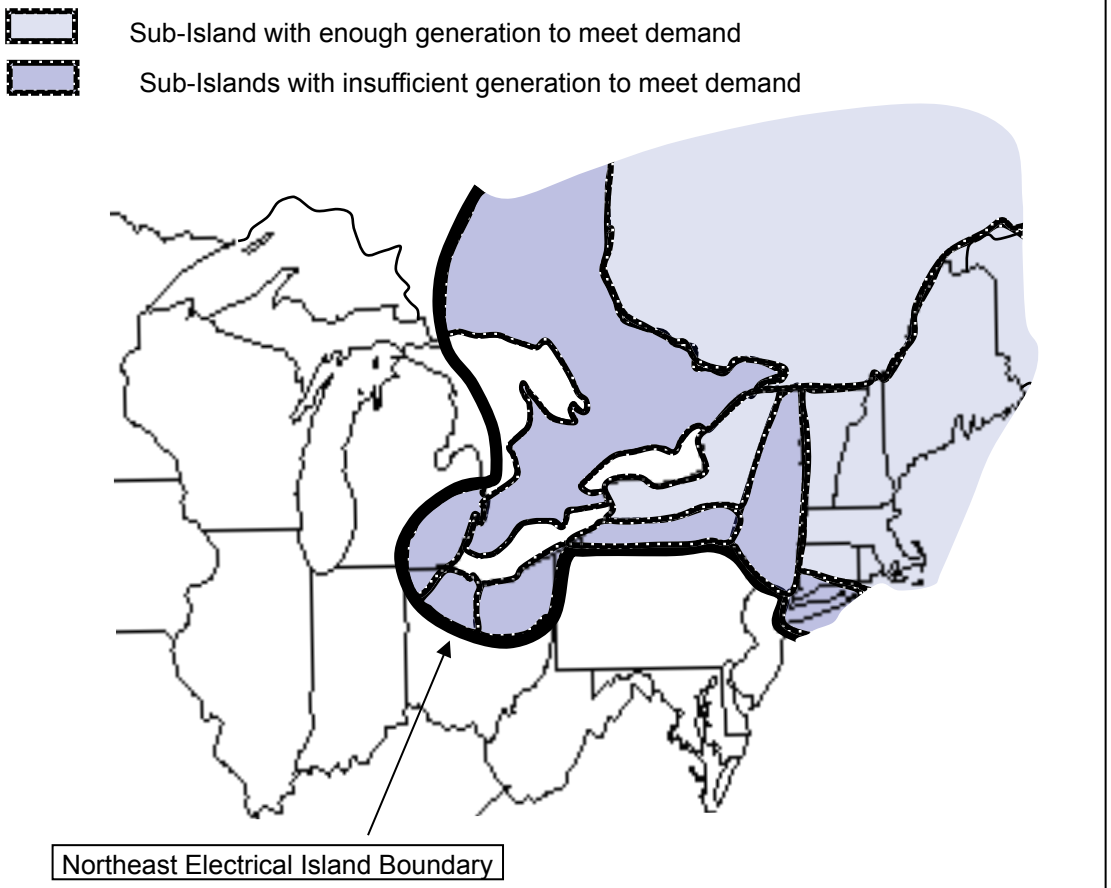
Northeast US – AUG 14th, 2003



	Before 1:31 PM	1:31 PM	3:05 PM	3:32 PM	3:41 PM	4:05 PM	Cause
East Lake 5 Plant	100% (600MW)	Failed	Failed	Failed	Failed	Failed	Exceeding MVAR limit
Harding-Chamberlain	35% (400MW)	45% (500MW)	Failed	Failed	Failed	Failed	Tree Contact
Juniper-Hanna	55% (800MW)	70% (1 GW)	80% (1.2 GW)	Failed	Failed	Failed	Tree Contact
Star-South Canton	65% (650MW)	80% (800MW)	90% (900MW)	120% (1.2 GW)	Failed	Failed	Overaload
Star-Sammis	55% (650MW)	60% (700MW)	65% (800MW)	85% (1 GW)	120% (1.4 GW)	Failed	Overaload



	Before 1:31 PM	1:31 PM	3:0
East Lake 5 Plant	100% (600MW)	Failed	
Harding-Chamberlain	35% (400MW)	45% (500MW)	
Juniper-Hanna	55% (800MW)	70% (1 GW)	80%
Star-South Canton	65% (650MW)	80% (800MW)	90%
Star-Sammis	55% (650MW)	60% (700MW)	65%



NYC $1 Billion

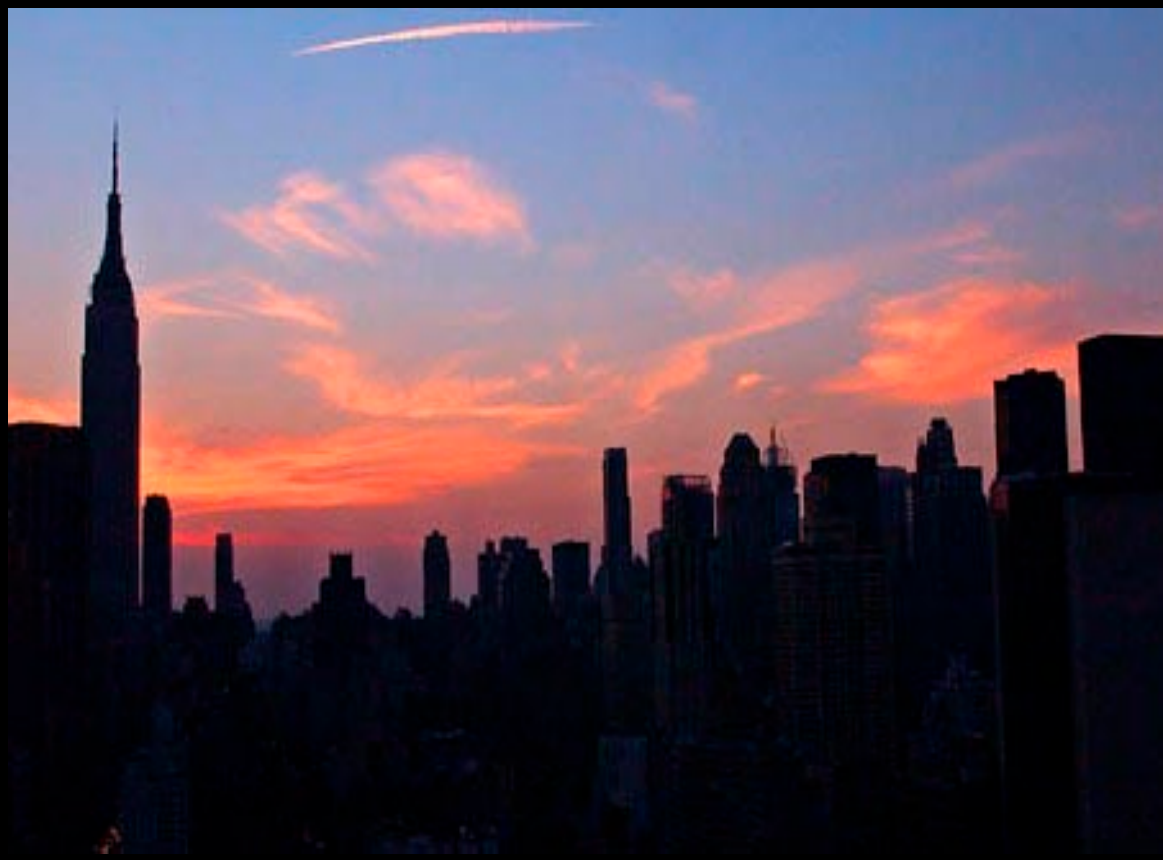
(Reuters)

$1.1 Billion

(The Guardian)

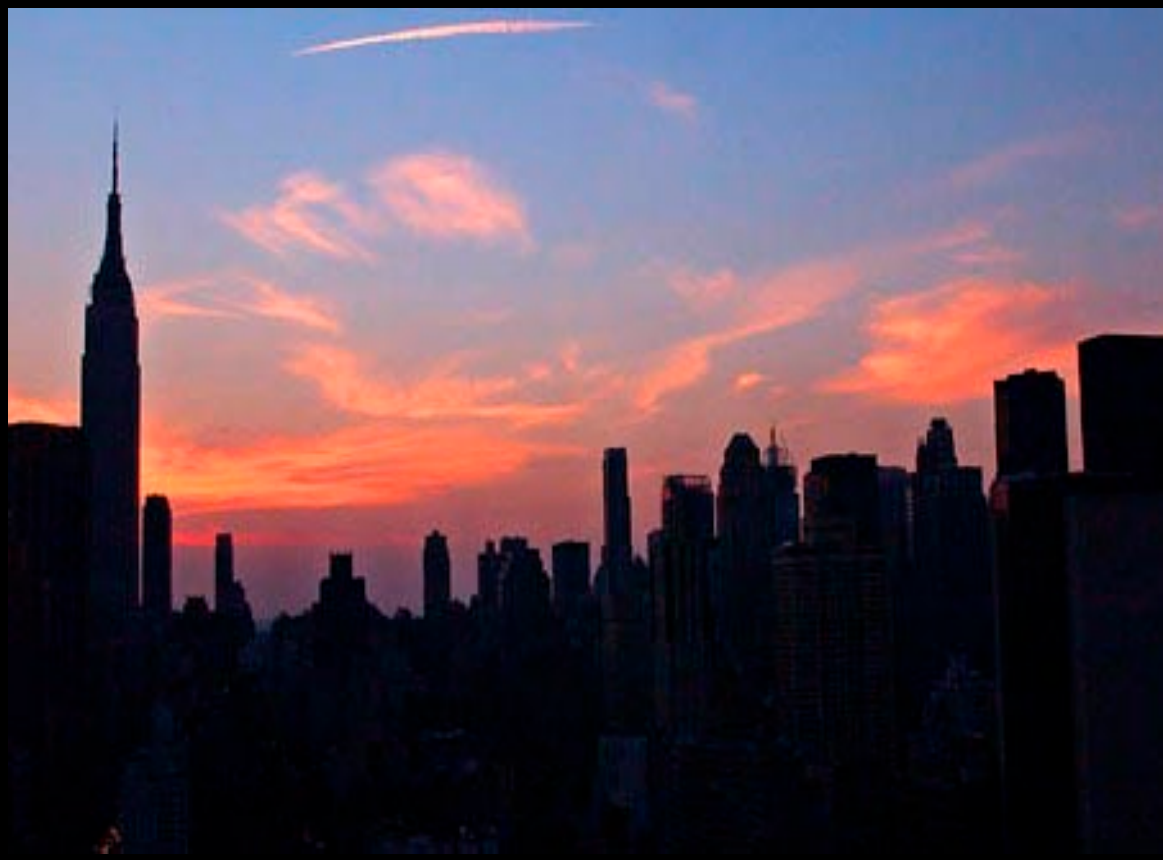
US-Can $6.8 - $10.3 B

(ICF Consulting)




PV

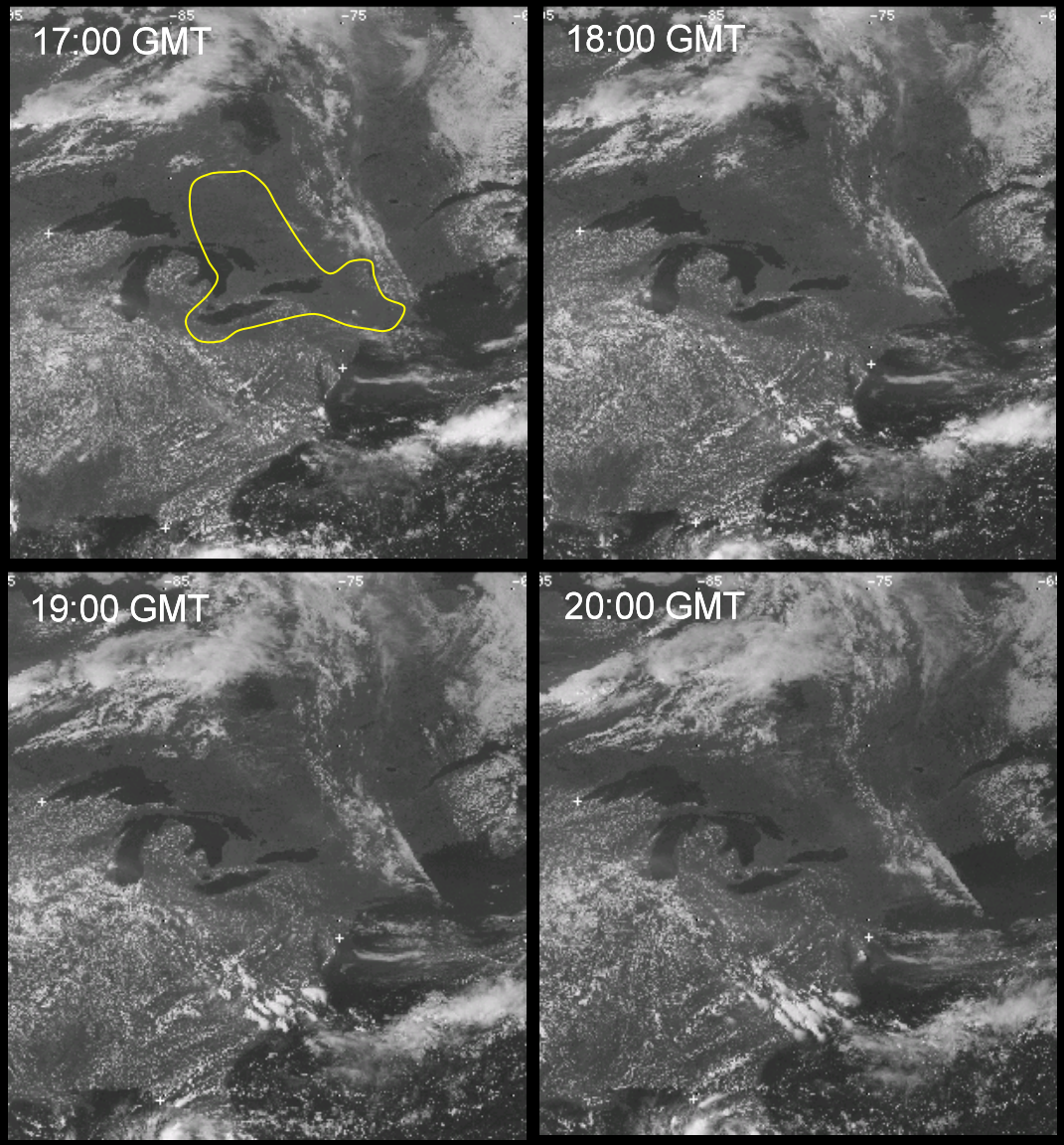
?



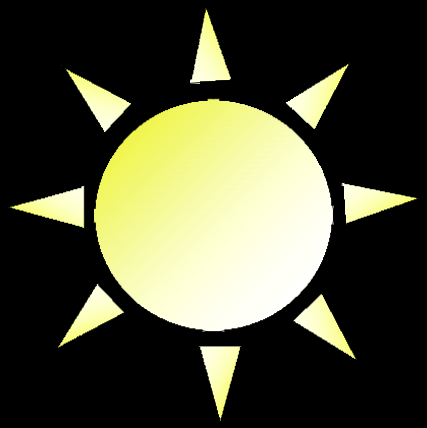
As little as 500 MW of PV dispersed around the major northeastern cities would have prevented the blackout

An investment of $ 3 billion

Outage cost $ 8 billion



SOLAR RESOURCE



- ~~NOT~~ ENOUGH SPACE,
- ~~NOT~~ ENOUGH SUN,
- ~~NOT~~ RELIABLE
- TOO EXPENSIVE …

…TOO EXPENSIVE…

Ralph Izzo, Chairman, PSEG:

"We've got to stop pretending solar power will lower the cost of energy.

It's going to increase the cost and people have got to understand why it is worth more"

Wall Street Journal 7/31/09

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…TOO EXPENSIVE…

VALUE

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Wall Street Journal 7/31/09

Solar delivers value

Solar delivers value

PV OWNER

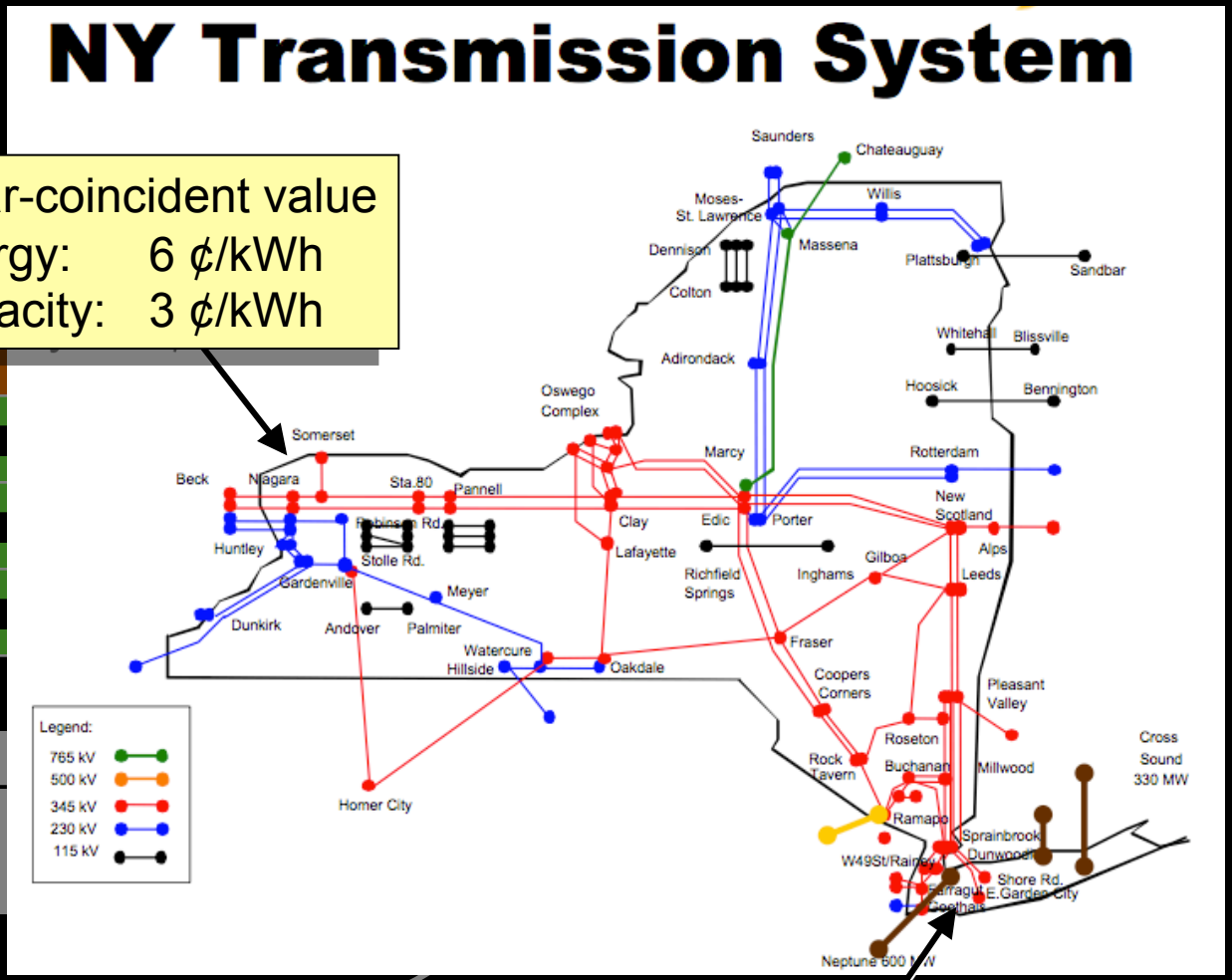
	PV OWNER	UTILITY	CONSTITUENTS
EQUIPMENT	COST		

	PV OWNER	UTILITY	CONSTITUENTS
EQUIPMENT	COST		
INCENTIVES	BENEFIT		COST
UTILITY BILLS	BENEFIT	COST	
TAX EFFECTS	BENEFIT		COST

EQUIPMENT
INCENTIVES
UTILITY BILLS
TAX EFFECTS

Solar-coincident value
Energy: 6 ¢/kWh
Capacity: 3 ¢/kWh

TRANSMISSION LEVEL
Energy
Capacity



Mean 24 hour value
Energy: 5 ¢/kWh
Capacity: 0 ¢/kWh for solar

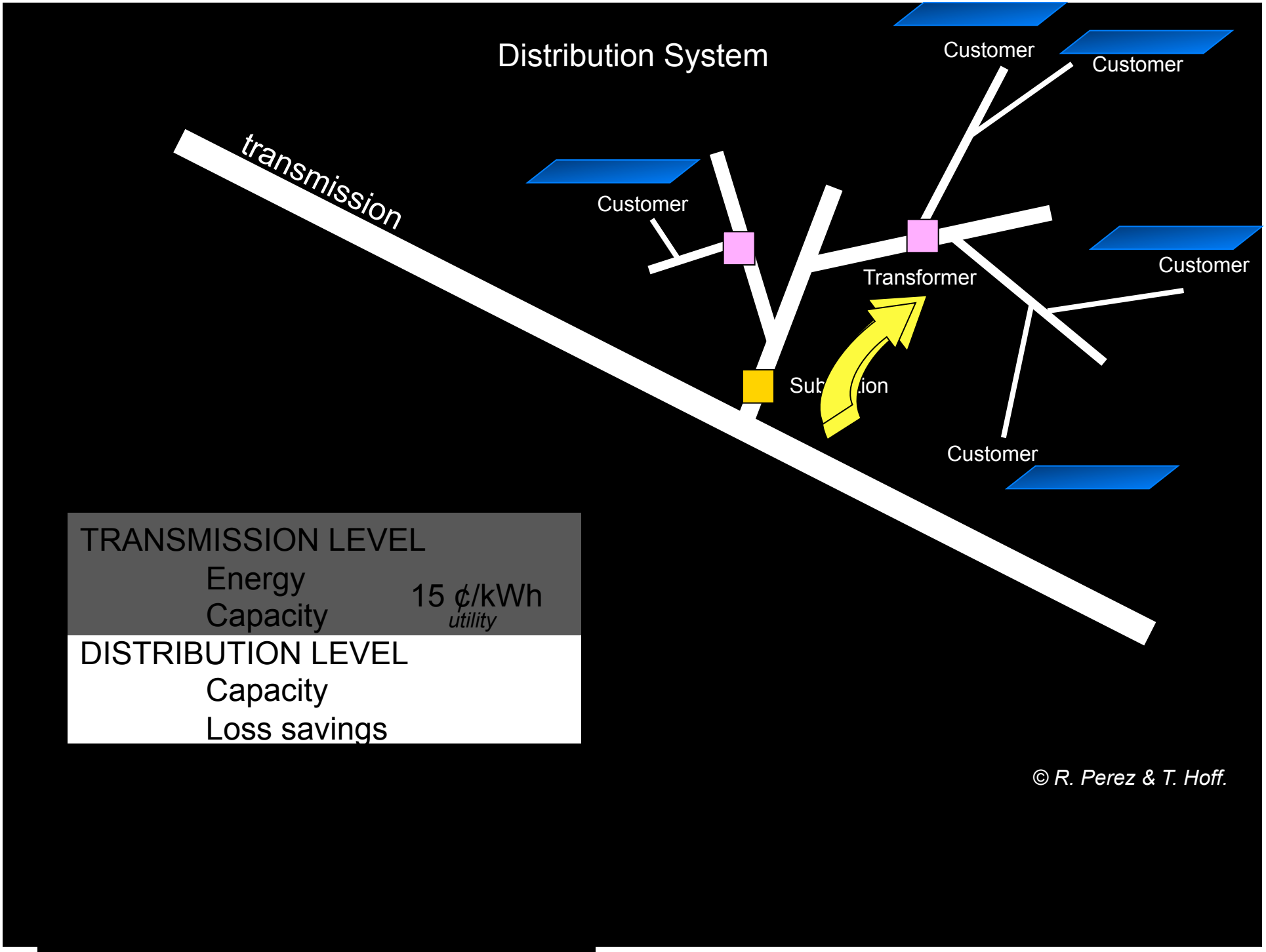
Energy: 11 ¢/kWh
Capacity: 5 ¢/kWh

	PV OWNER	UTILITY	CONSTITUENTS
EQUIPMENT	COST	BENEFIT	BENEFIT
INCENTIVES	BENEFIT		COST
UTILITY BILLS	BENEFIT	COST	
TAX EFFECTS	BENEFIT		COST

TRANSMISSION LEVEL

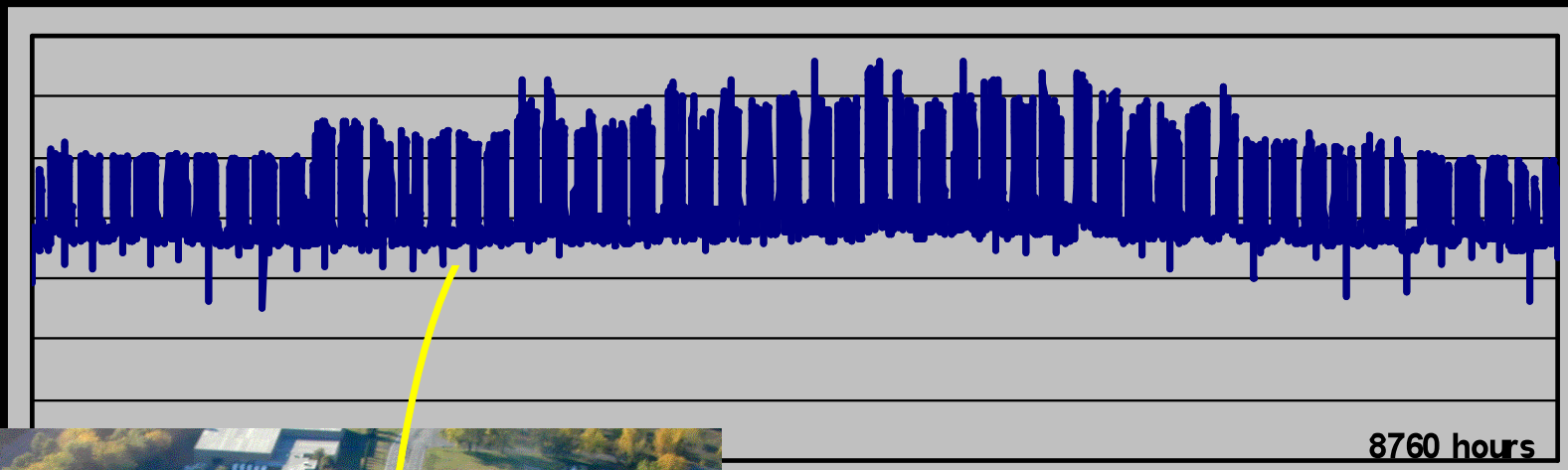
Energy
Capacity

15 ¢/kWh
utility

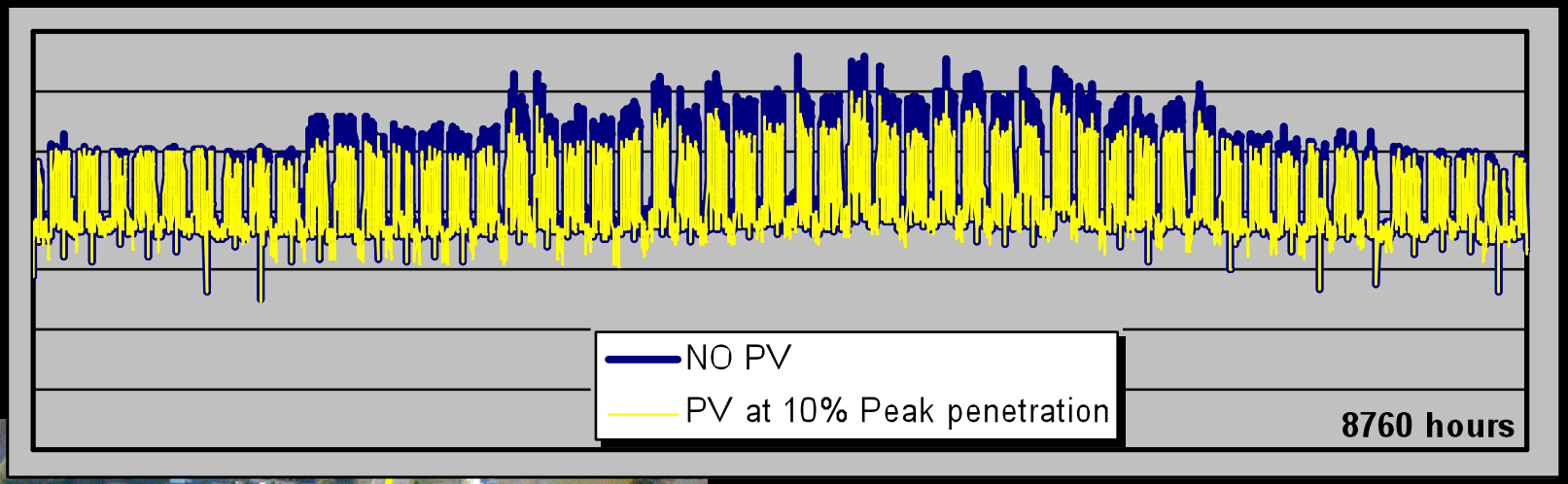

Distribution System
transmission
Customer
Customer
Customer
Customer
Customer
Transformer
Sub ion
TRANSMISSION LEVEL
Energy
Capacity
15 ¢/kWh
utility
DISTRIBUTION LEVEL
Capacity
Loss savings
© R. Perez & T. Hoff.

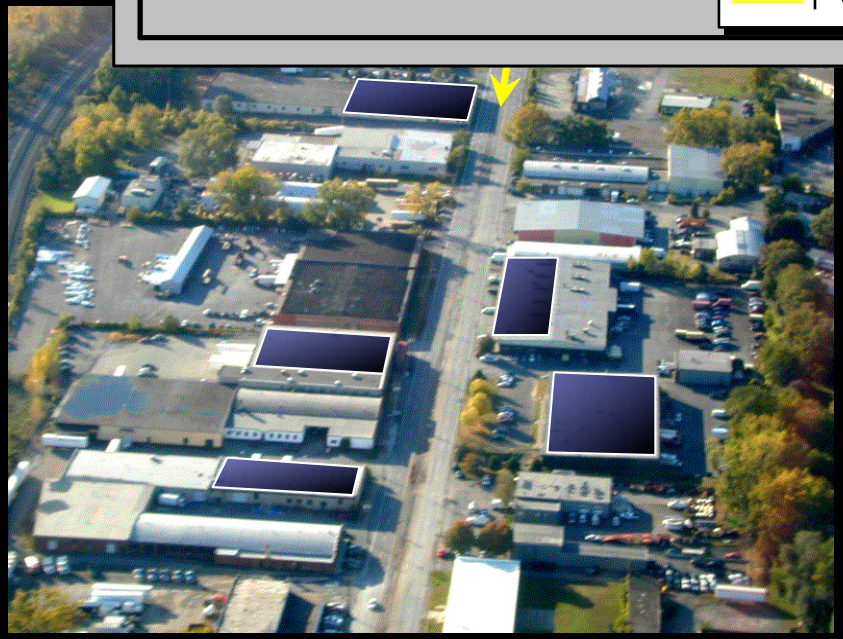
Power flow

ELECTRICAL DEMAND THROUGHOUT ONE YEAR

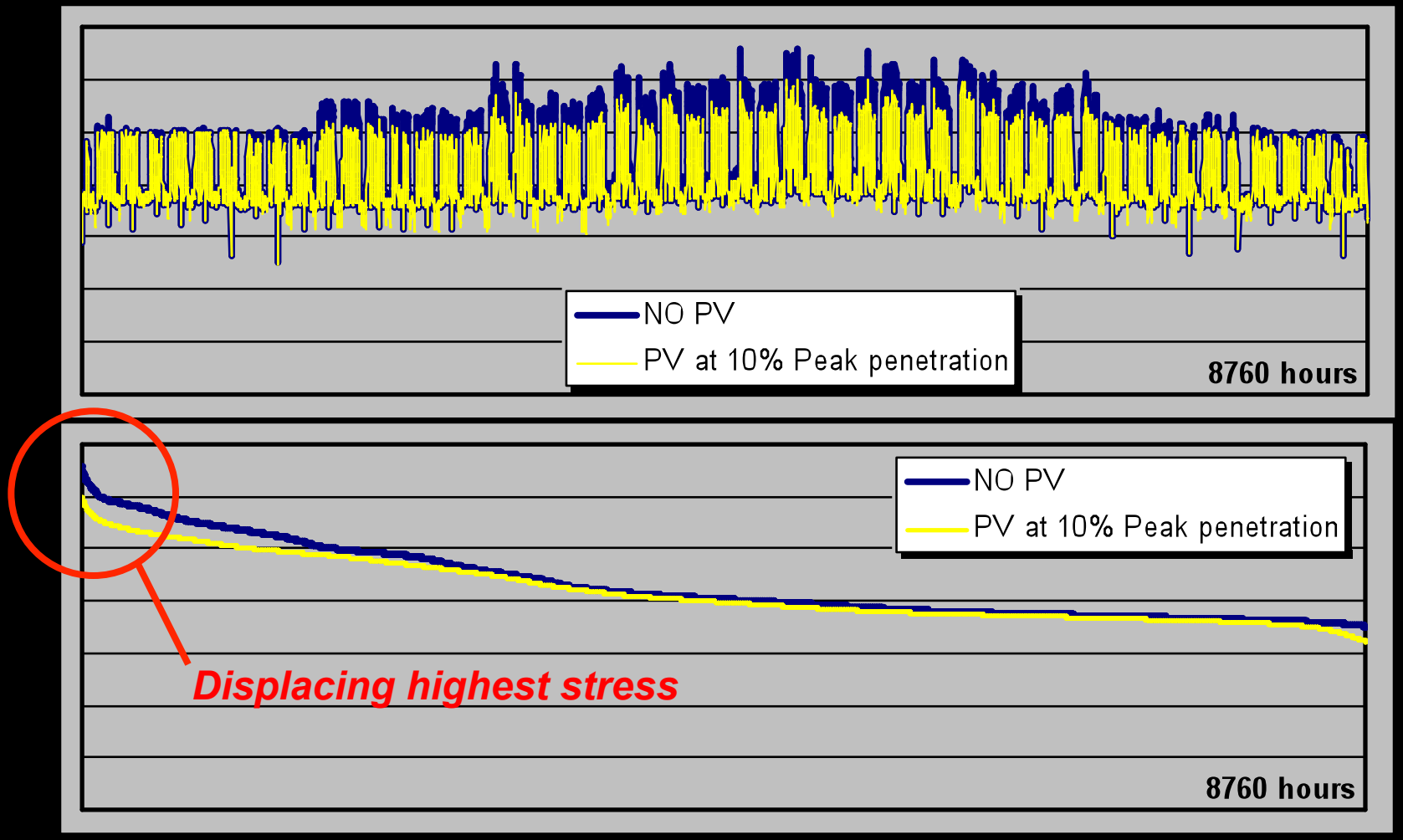


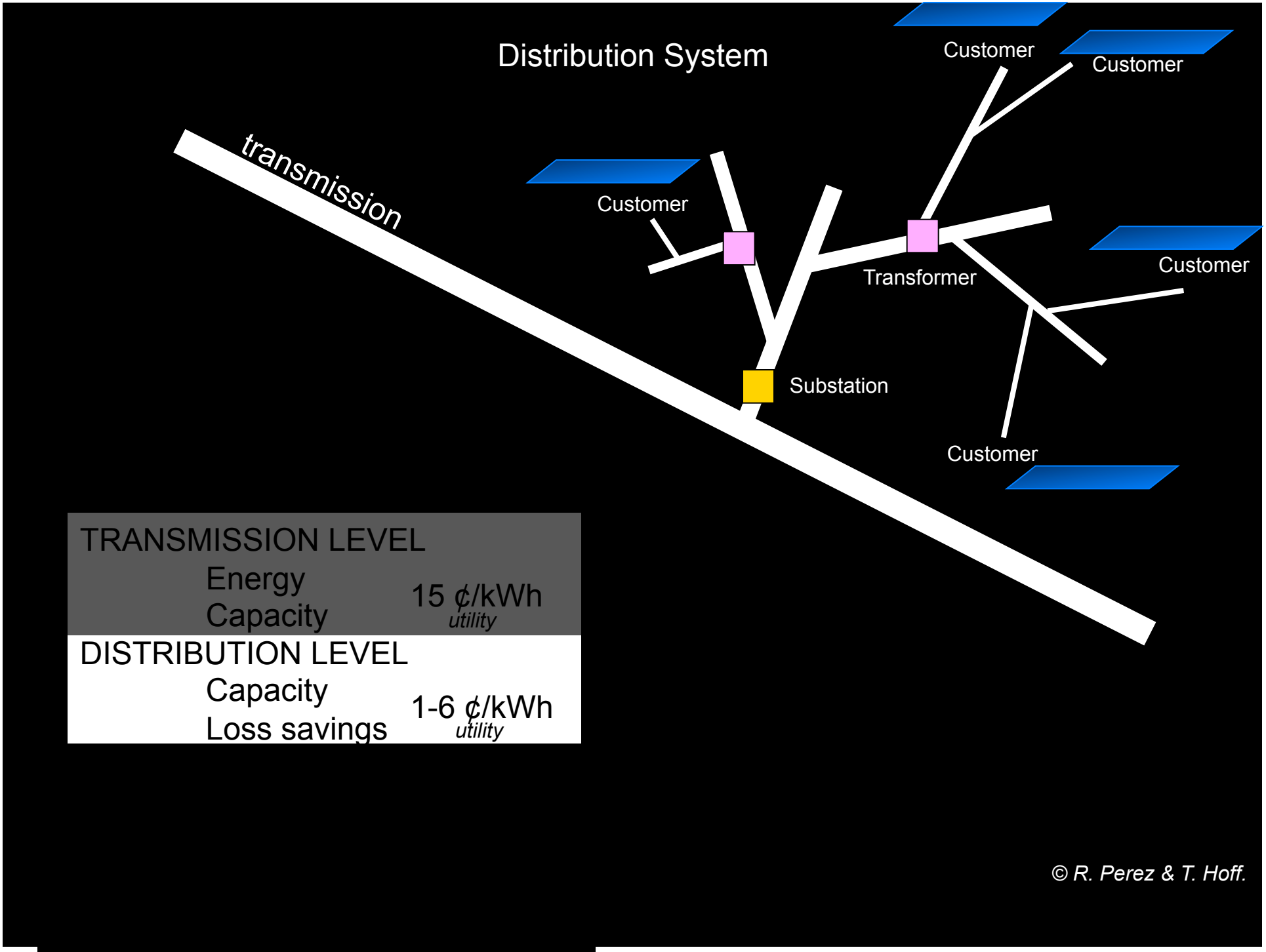
ELECTRICAL DEMAND THROUGHOUT ONE YEAR

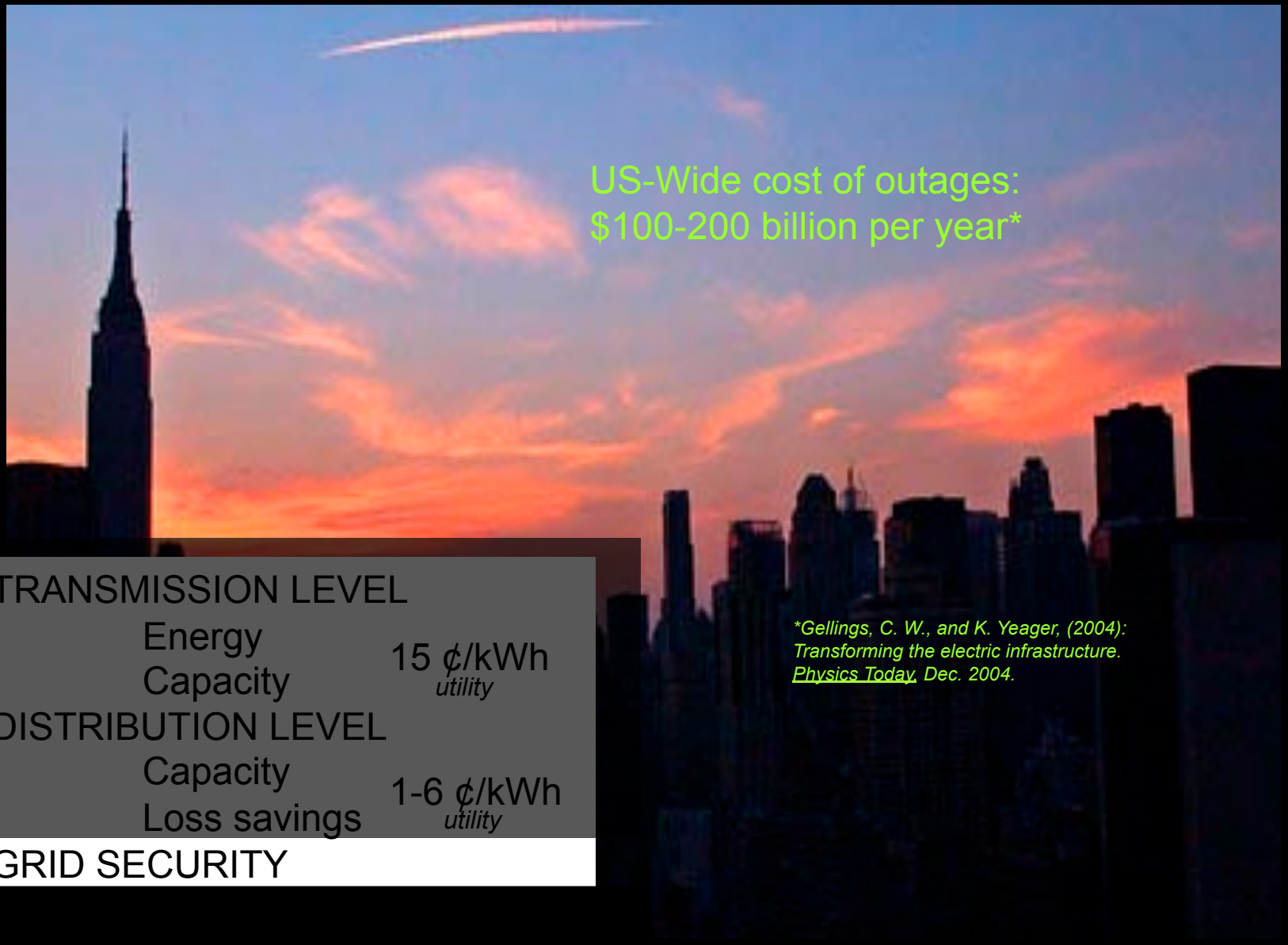




PV IMPACT AT 10% CAPCITY PENETRATION




Distribution System
transmission
Customer
Customer
Customer
Transformer
Customer
Substation
Customer
TRANSMISSION LEVEL
Energy
Capacity
15 ¢/kWh
utility
DISTRIBUTION LEVEL
Capacity
Loss savings
1-6 ¢/kWh
utility
© R. Perez & T. Hoff.



TRANSMISSION LEVEL

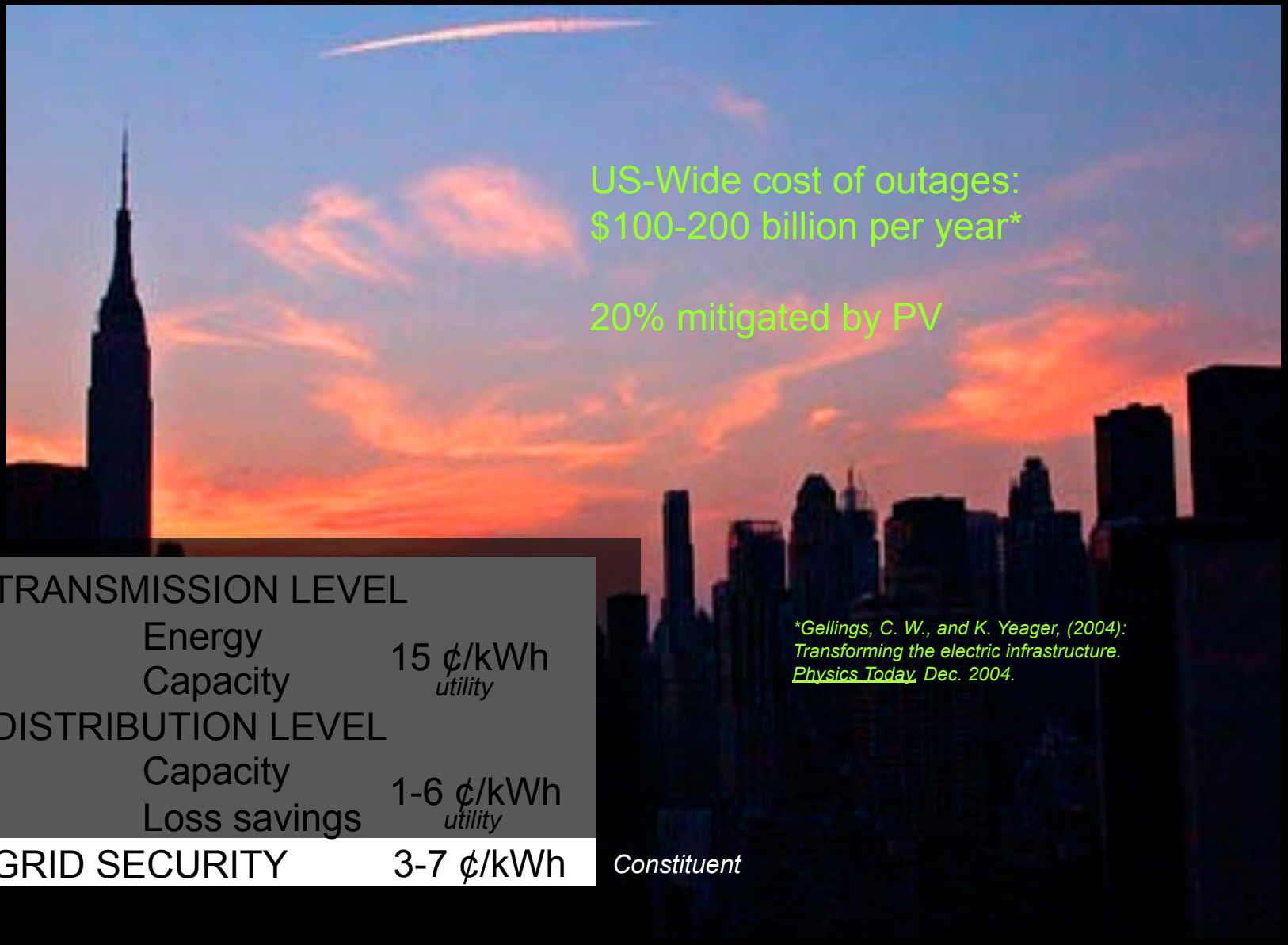
Energy
Capacity — 15 ¢/kWh *utility*

DISTRIBUTION LEVEL

Capacity
Loss savings — 1-6 ¢/kWh *utility*

GRID SECURITY

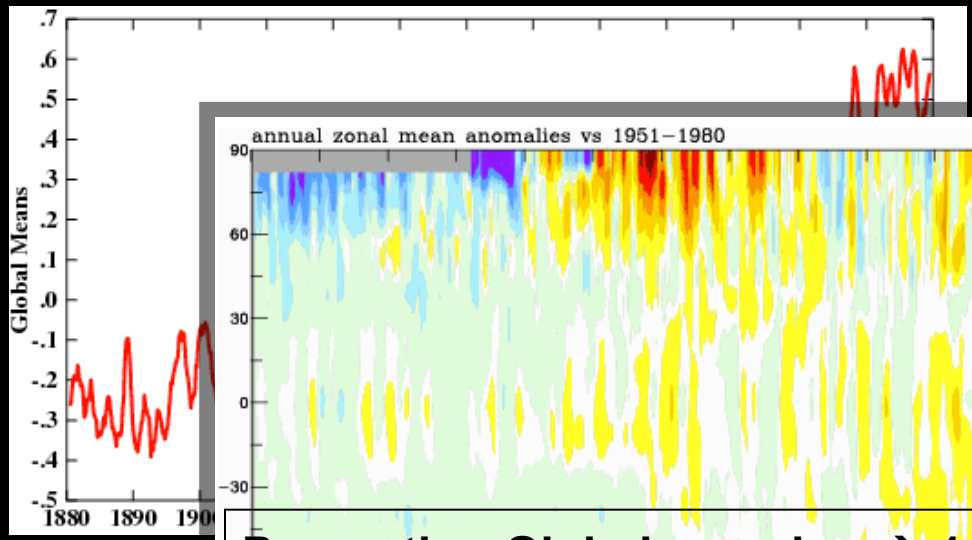
**Gellings, C. W., and K. Yeager, (2004): Transforming the electric infrastructure. Physics Today, Dec. 2004.*



TRANSMISSION LEVEL		
	Energy Capacity	15 ¢/kWh *utility*
DISTRIBUTION LEVEL		
	Capacity Loss savings	1-6 ¢/kWh *utility*
GRID SECURITY	3-7 ¢/kWh	*Constituent*

**Gellings, C. W., and K. Yeager, (2004): Transforming the electric infrastructure. Physics Today, Dec. 2004.*

Global Warming



Preventing Global warming → 1.5% GDP

Fixing Global Warming → 25% GDP

TRANSMISSION LEVEL		
	Energy Capacity	15 ¢/kWh *utility*
DISTRIBUTION LEVEL		
	Capacity Loss savings	1-6 ¢/kWh *utility*
GRID SECURITY		3-7 ¢/kWh
ENVIRONMENTAL COMPLIANCE		

PV = 10% of solution

250 cents per kWh**

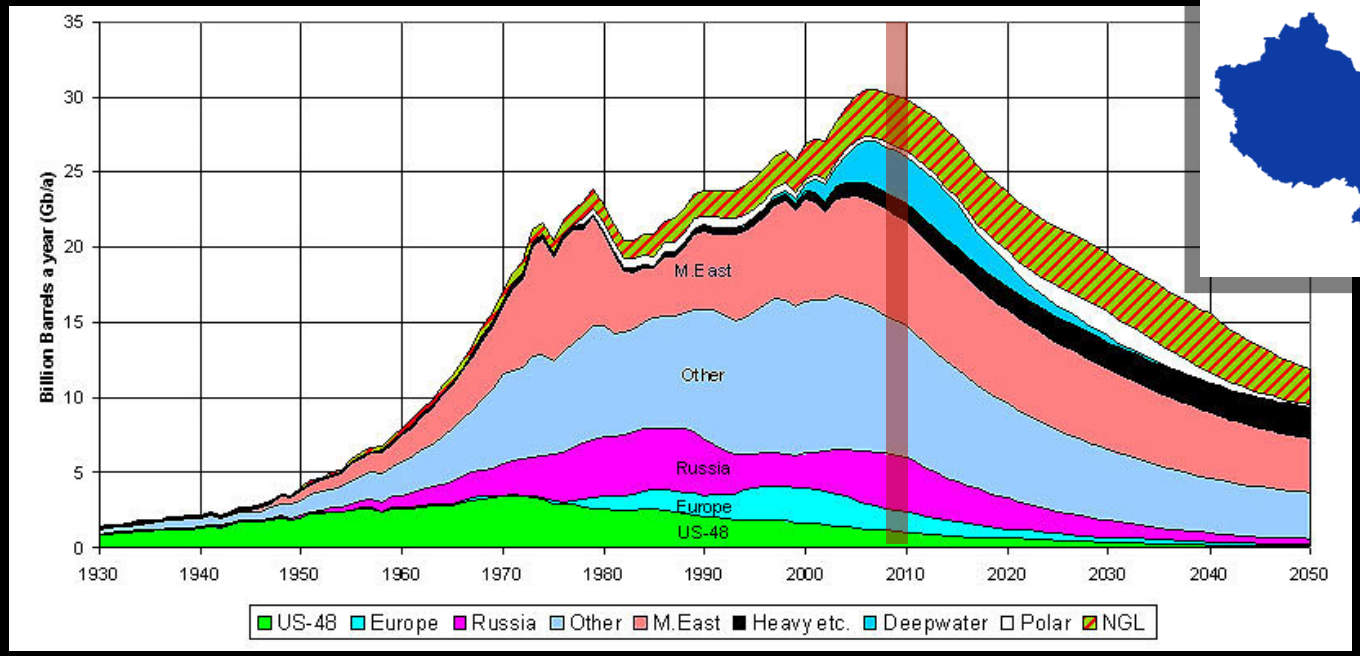
Constituent

2 cents per kWh est, @ $40/metric ton CO2*

* Based upon current NYS generation mix

** based upon 2010 PV industry size

TRANSMISSION LEVEL		
	Energy Capacity	15 ¢/kWh *utility*
DISTRIBUTION LEVEL		
	Capacity Loss savings	1-6 ¢/kWh *utility*
GRID SECURITY	3-7 ¢/kWh	*Constituent*
ENVIRONMENTAL COMPLIANCE	2–100's ¢/kWh	*Constituent*



TRANSMISSION LEVEL		
	Energy Capacity	15 ¢/kWh *utility*
DISTRIBUTION LEVEL		
	Capacity Loss savings	1-6 ¢/kWh *utility*
GRID SECURITY	3-7 ¢/kWh	*Constituent*
ENVIRONMENTAL COMPLIANCE	2–100+ ¢/kWh	*Constituent*
FUEL PRICE RISK MITIGATION	5-25+ ¢/kWh	*Constituent/utility*

Hedging $500/bbl oil in 2040:

NPV = 25 cents per kWh est.

Each megawatt (MW) of photovoltaic (PV) panels **manufactured** in the US employs 14 people.

Each MW of PV **installed on homes** in the US employs 14.3 people.

Each MW of PV **installed on commercial buildings** employs 9 people.

Each MW of PV **maintained** employs .3 people.

TRANSMISSION LEVEL		
	Energy	
	Capacity	15 ¢/kWh *utility*
DISTRIBUTION LEVEL		
	Capacity	
	Loss savings	1-6 ¢/kWh *utility*
GRID SECURITY	3-7 ¢/kWh	*Constituent*
ENVIRONMENTAL COMPLIANCE	2–100+ ¢/kWh	*Constituent*
FUEL PRICE RISK MITIGATION	5-25+ ¢/kWh	*Constituent/utility*
ECONOMIC GROWTH	2-3+ ¢/kWh	*Constituent*

PV VALUE: 30–100's ¢/kWh

PV COST W/O INCENTIVES TODAY: 30-45 ¢/kWh

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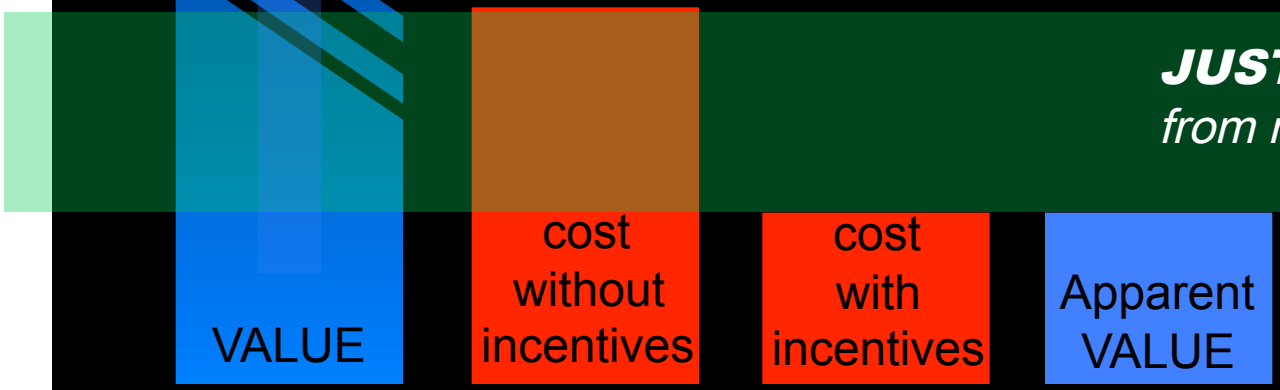
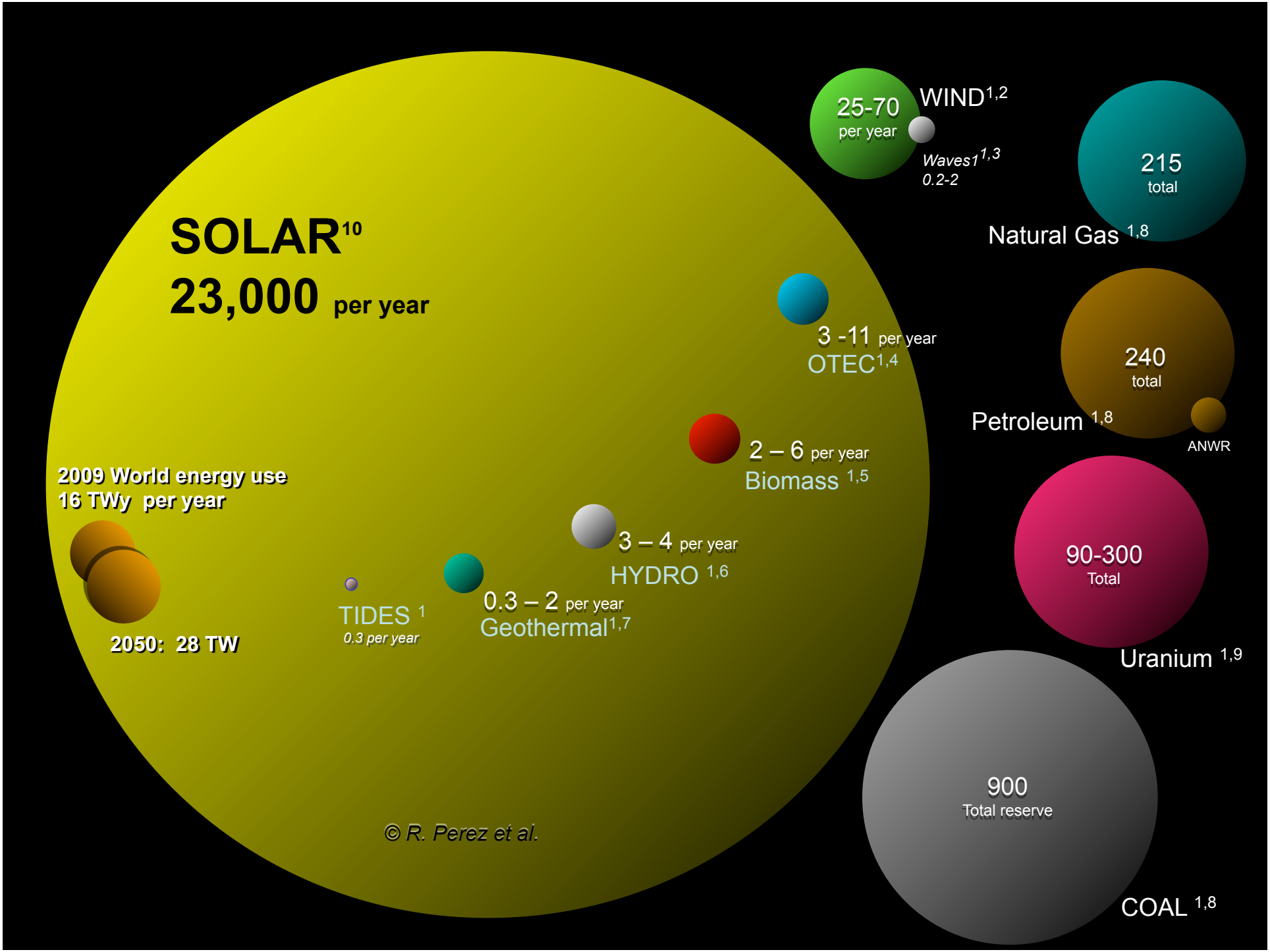
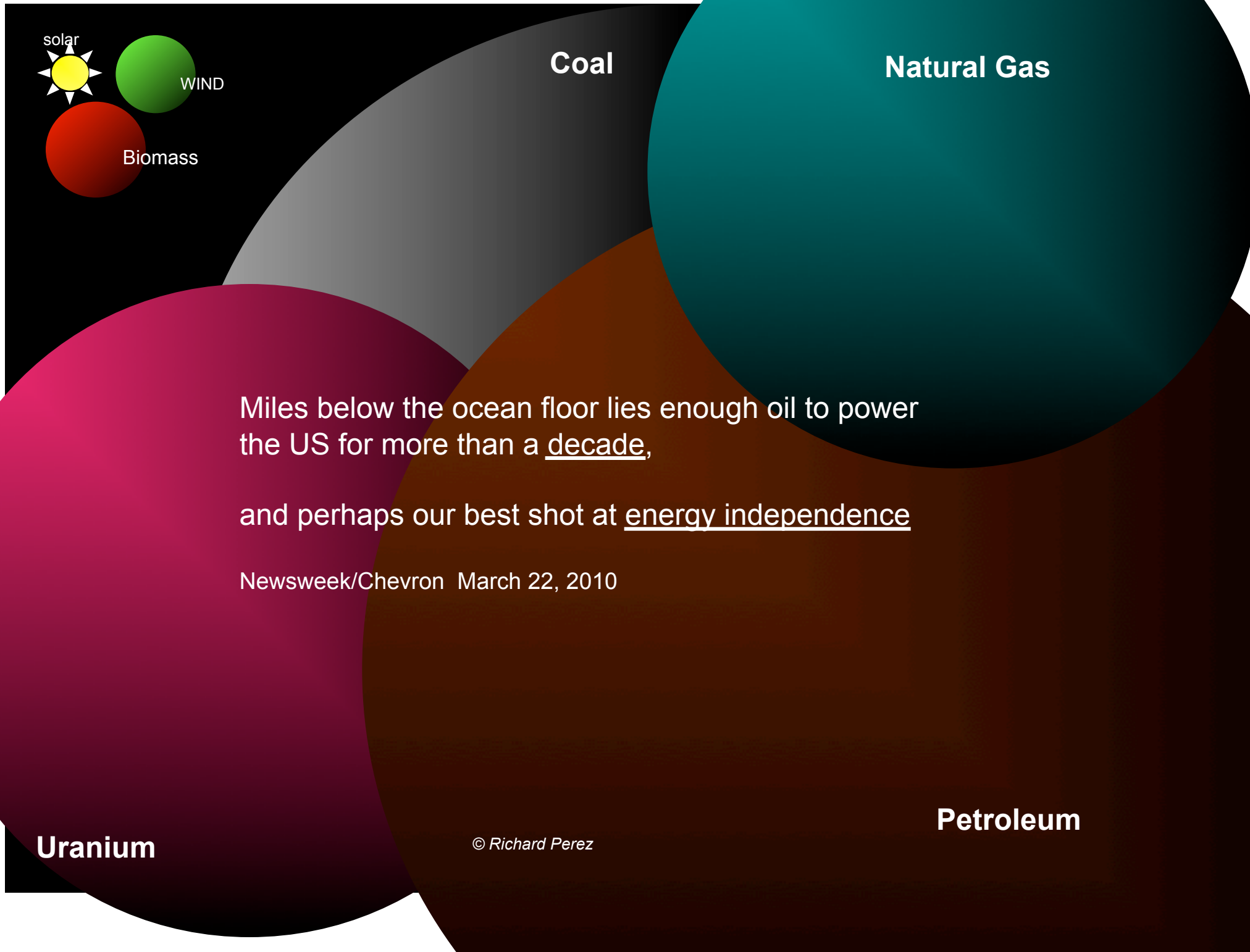


JUSTIFY INCENTIVES
from ratepayers & taxpayers

	PV OWNER	UTILITY (ratepayers)	CONSTITUENTS (taxpayers)
EQUIPMENT	COST	BENEFIT	BENEFIT
INCENTIVES	BENEFIT		COST
UTILITY BILLS	BENEFIT	COST	
TAX EFFECTS	BENEFIT		COST

Ratepayers = Taxpayer = You and me


SOLAR[10]
23,000 per year
2009 World energy use
16 TWy per year
2050: 28 TW
25-70
per year
WIND[1,2]
Waves[1,3]
0.2-2
215
total
Natural Gas [1,8]
3 -11 per year
OTEC[1,4]
240
total
Petroleum [1,8]
ANWR
2 – 6 per year
Biomass [1,5]
3 – 4 per year
HYDRO [1,6]
90-300
Total
Uranium [1,9]
TIDES [1]
0.3 per year
0.3 – 2 per year
Geothermal[1,7]
900
Total reserve
COAL [1,8]
© R. Perez et al.


solar
WIND
Biomass
Coal
Natural Gas
Miles below the ocean floor lies enough oil to power the US for more than a decade,
and perhaps our best shot at energy independence
Newsweek/Chevron March 22, 2010
Uranium
© Richard Perez
Petroleum